THE PLANT COMMUNITIES OF DISUSED RAILWAY BALLAST IN GREAT BRITAIN

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SUMMARY

Disused railway lines make excellent vehicles to study ecological processes being linear, of fixed width, constructed in the same way, with potential vegetation influences such as time since abandonment and climate being easy to discover. Moreover they are rarely studied. Thus the current study fills a gap in the literature.

Samples were taken from a total of 176 releves across 35 sites on 22 different railway lines within England and Wales. The communities were analysed using the standard UK phytosociological method, the National Vegetation Classification (NVC). Few similarities were found with published NVC communities. A large number of communities had affinities with MG1 *Arrhenatherum elatius* grassland but with un-described sub-communities, with ruderal species or wood and scrub species as major components. Similarly, a number of communities had affinities to OV communities but with different constant species. Hence it is difficult to apply the NVC to synanthropic habitats and that there are ruderal communities in existence that are not described in the NVC.

A modified Braun-Blanquet approach to analysing the vegetation data was also undertaken. Hierarchical analysis identified seven clusters equating to communities. Species characteristic of each community were identified using Indicator Values, although these species rarely had both high fidelity and exclusivity.

The potential contribution of environmental, temporal and edaphic variables to the development of these communities was assessed. This was underpinned by the

theoretical question of succession. Is it an ordered progression through to a climax community or is the process much more stochastic ?

There is no simple relationship between time since abandonment and any measure of successional progress. However CCA analysis showed that some factors, primarily abiotic, were significantly associated with community composition. Time since abandonment only becomes significant when it is combined with soil factors. This suggests that vegetation composition is not entirely random in these communities.

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CONTENTS

CHAPTER 1 - INTRODUCTION

Describing and defining plant communities is one of the fundamental practices of ecology. Debate over how to define plant communities has been occurring over a long period of time. In the early 1900s two American ecologists, F.E. Clements (1905 & 1916) and H.A. Gleason (1926) had opposing opinions on how plant communities should be recognised. Clements believed that plant communities were organismic, comprising “recognizable and definable groups of plants” (in Kent & Coker, 1992) occurring in more than one place. In contrast Gleason held an opposing opinion believing in the individuality of each plant community, with the plant species distribution determined by external factors such as the environmental conditions.

At present, most ecologists worldwide lean towards Clements’ concept that plant communities can be defined by their species composition and grouped into types (Kent & Coker, 1992). For instance Pott (1992) defines a plant community as ‘all the plants growing in a certain terrain (*Phytozönosen* – vegetation unit) whereby within this specific terrain all the plants are ‘related’, meaning they have the same or very similar characteristics”. Traditionally, the floristic composition of plant communities, rather than the habitat that they occur in, has been used to classify each group of plants no matter what part of the world they are located in.

The idea that plant communities are dynamic and the processes by which a community establishes have also long been debated. Originally, ecologists such as Clements argued in favour of a climax community, which was reached through a progression of linear successional stages. Typically, these were pioneer species, through to grassland and perennial establishment through to scrub and then onto woodland. This final community could only change through disturbance (e.g. fire, felling or death). More recently, ecologists view community establishment as more random and unpredictable (Walker & del Moral, 2003).

Whatever the variation in definition, the recognition that plant communities exist leads on to the need to describe them. This description of communities is termed phytosociology. This field of ecology originated in Europe in the early 1800s (e.g. Humboldt, 1805). Faced with the problem of recognising, sampling and quantifying the features of a plant community; plant abundance (i.e. the number of individuals), cover (the amount of ground covered by a species), clustering pattern (single, regular, grouped etc.) and fidelity species (species restricted to a single community), three main schools of approach developed: the Zurich-Montpelier school, the Uppsala school and the Raunkiaerian School with key differences to sampling and describing these components. Shimwell (1971) provides a detailed explanation of the history of each school.

The Zurich-Montpelier school included such eminent plant ecologists as Rűbel, Tüxen and Braun-Blanquet. The most notable of this group, Braun-Blanquet, was a pioneer in the field of phytosociology and developed a method of classifying plant communities that continues to be used as the basis for classifying plant communities across much of mainland Europe.

The Braun-Blanquet (hereafter known as Br-Bl) system was published in 1928. As originally used, the Br-Bl technique is lengthy and is not easily described in any publication of the period. The technique works by assuming the ecologist already has a detailed understanding of the vegetation he/she is about to study and can spot homogenous areas in the field easily. The concept is based on plant associations (association can be defined as “a plant community of definite floristic composition presenting a uniform physiognomy and a growing in uniform habitat conditions” Flauhault, 1910) which are defined by ‘fidelity’ or faithful species, which only occur in one association and no other. “Fidelity is the most fundamental notion of the Br-Bl approach…it is also the concept through which this school differs from all other schools of vegetation science” (Barkman, 1989).

The Br-Bl technique works by firstly determining a homogenous plant community in the field. Once found, a relevé (or quadrat) was created using the minimal area calculation i.e. keep doubling the size of the relevé until no new plant species were being found. As part of the data gathering technique, Br-Bl amalgamated cover and abundance by developing a six-point scale, to be assigned to each species, from ‘x’ meaning sparsely present, cover very small up to ‘5’ meaning covering more than ¾ of an area. The Br-Bl technique is also unusual in that it also uses a scale of sociability. The sociability scale is a five-point scale ranging from 1 meaning the plant is growing in a single place up to 5 meaning the plant is growing in great crowds of pure populations. This allows for a better understanding of the community structure and how the vegetation is organized within that community. So far, no other phytosociology system has used sociability to describe plant communities. Following the field work, association tables would be created, looking for faithful species which defined that particular community. A hierarchical system would emerge with the association with its faithful species, followed by alliance, order and class.

The Uppsala School (pioneered by Du Rietz), surveying typically species-poor, generally uniform vegetation in Scandinavia, developed the term ‘sociation’ for a vegetation unit and described such using constancy, abundance and dominance. The Uppsala School, in contrast to the Br-Bl outlook, believed the sociation was a ‘real’ unit which could be distinguished in the field then analysed with quadrats, whereas Br-Bl believed studying homogenous vegetation with quadrats first would lead to an association through calculations of tables. The Uppsala school also used a hierarchical classification, similar to Br-Bl but preferring to delineate micro-associations rather than large associations.

Neither of these methodologies used random quadrats whereas the Raunkiaerian School (Raunkiaer, 1924) or Danish School did. Homogenous stretches of habitat were chosen by eye then a series of random quadrats thrown, all measuring $0.1m^2$. Species recorded were marked present or absent depending on where the quadrat landed. Each species was assigned a frequency depending on the percentage of times it occurred in a quadrat. Raunkiaer also introduced the idea for his ‘formations’ to be assessed by their physiognomy (calculation of proportion of each species present) and their biological life forms (each species being assigned a life form type then the frequency of each type calculated to assess the typical life form of a formation). For example, Raunkiaer split his plants into Nanophanerophytes, Chamaephytes, Hemicryptophytes and so on.

Two of the schools have fallen out of favour over the years. The Raunkiaer approach proved to have limited use, mainly being applied in Denmark and is currently rarely used. The Uppsala School eventually converged its ideas with those of Br-Bl although it is still used to some degree in Sweden. In contrast, Br-Bl approaches are extensively used in mainland Europe, with recent studies on Dutch grasslands (Werger, 1973), on the Czech national dataset (Chytry & Tichy, 2003), Italian asbestos mine dumps (Favero-longo *et al*, 2006) and Russian lowland habitats (Mirkin & Naumova, 2009). Further afield, Br-Bl is also used chosen as a method of vegetation classification with recent studies on North American alpine communities (Peinado *et al,* 2005a + b), Iranian woodlands (Hamzeh'ee *et al*, 2008) and Ethiopian riverine habitats (Tikssa *et al*, 2009). In addition, Becking (1957) described a methodology for using Br-Bl in America, as American ecologists previous to this had encountered problems using the European methods on their vegetation. With the rise of computer access and power, the Br-Bl methodology has been adapted (e.g. the sociability scale has been removed from the methodology) with the aim of reducing subjectivity and is now rigorously tested using computerised statistical analysis such as Juice (Tichy, 2002).

Other software packages have been developed which aim to statistically test the progression of plant communities and the factors which influence them, to enable a greater understanding of succession. Multivariate analysis is often undertaken using Canonical Correspondence Analysis (CCA), (e.g. Caccianiga, 2006) which allows the comparison of numerous datasets such as abiotic factors, time and species lists.

Historically, the Br-Bl technique has been criticised by British ecologists. Arguments range from the methodology being too subjective, difficult to use and only workable in landscapes which have clearly defined plant community boundaries (e.g. Poore, 1955b & Poore, 1956). This is possibly because Britain has less diverse habitat ranges than most other European countries and more homogenous agricultural landscapes.

Tansley was among the first ecologists to classify semi-natural plant community types in Britain. He defined plant communities as “the unity of life impressed upon an aggregate of plants living together under common conditions (i.e. in a common habitat)” (Tansley, 1939). Tansley adhered to the ‘organismic’ view of a plant community, i.e. the community grows, matures and dies and he leaned heavily on succession and described mainly climax communities. His method lacked the hierarchical classification of the continental schools. Instead Tansley introduced far more descriptive elements such as soil type, plant profiles and the structure of the community and it is this approach utilised in his classic *British Isles and their Vegetation* (Tansley, 1939).

However Tansley’s approach was largely ignored until Poore described Scottish montane vegetation (1955a, 1955b & 1955c) using a hybrid Br-Bl approach, largely using the Zurich-Montpelier system with components of the Uppsala methodology (Poore & McVean, 1957).

Subsequently McVean and Ratcliffe (1962) used Poore’s ‘hybrid’ methodology to describe Scottish Highland Vegetation. Further British phytosociological work was undertaken by Williams and Varley (1967) on the grassland communities of the Yorkshire fells again using the hybrid methodology. Shimwell (1968) studied calcareous grasslands in Northern England using a more true Br-Bl approach including the sociability scale.

Between 1975 and 2000, Rodwell and his team at Lancaster University were commissioned to work on categorizing the British flora into distinct communities. This became *British Plant Communities Volumes 1 to 5* (1995 – 2000) and the methodology was named National Vegetation Classification (NVC). The NVC is broadly based on the concepts developed by Tansley but has borrowed ideas from the Continental approach to phytosociology.

The NVC is essentially a hybrid approach utilising elements of both Br-Bl and Uppsala approaches. As such it largely follows Poore (1955a, b & c) by pre-selecting quadrat size depending on the type of vegetation being studied (i.e. woodland, grassland etc.) and by using Domin scores when surveying the vegetation. No sociability score is used in NVC. Similarly to Br-Bl, Rodwell based all of his analysis on the floristic information only and used environmental data only when describing the communities. The NVC differs from the Br-Bl methodology in that Rodwell bases the plant communities on constant species rather than fidelity species. There are some NVC communities which have the same predominant species in their composition as others and therefore in their title (e.g. CG8 *Sesleria albicans-Scabiosa columbaria* grassland and CG9 *Sesleria albicans-Galium sterneri* grassland). Rodwell also took the decision not to ignore samples that were analogous to the stand of vegetation sampled. With the Br-Bl method, any sample which appears to be different from the rest that describe the vegetation, is rejected and removed from the association table.

British Plant Communities Volumes 1 to 5 (1995 – 2000) is a monumental work and since its publication the NVC has become the standard phytosociological approach to British vegetation. Extensive as the NVC coverage undoubtedly is the coverage of ruderal communities is sparse (Rodwell, 2000) and certainly less extensive than the coverage of, for example, woodlands and calcareous grasslands. This is further recognised in Rodwell (2000). One of the aims of this study is to address this deficit. The study will also lead to a list of species found in these habitats. Species assemblages and numbers, rather than simple presence of rare species, were used by Ratcliffe (1977) as a means to identify sites of conservation value. This in turn led to such an approach being a key component of identifying sites for SSSI classification (NCC, 1989). The approach has subsequently been used in a number of UK conservation approaches including Common Standards Monitoring (e.g. www.jncc.gov.uk/page-2217) and non statutory sites. An additional aim is to address whether species assemblages can be used to assess the value of ruderal sites.

In part this absence of coverage reflects the extent of previous interest in such communities within the UK. By comparison elsewhere there is a long history of research into ruderal communities. Within Europe there has long been an acceptance that ruderal assemblages could be characterized and classified as with other communities and hence interest in the phytosociology of weed vegetation (Rodwell, 2000).

This might be seen as a missed opportunity by British ecologists. Studying artificial substrates is advantageous to the ecologist (Bradshaw, 1970). They give the ecologist a chance to witness and describe pioneer plant succession. Moreover, a detailed history of the substrate is often available, for example, time since abandonment allowing some ecological variables to be quantified. Many artificial substrates go on to support incredibly species-rich plant and invertebrate assemblages (Shaw, 1990). The term ‘synanthropic’ is often used for these habitats, meaning associated with mankind. Of course, many habitats could be described as being synanthropic due to being affected (or managed) by man such as grasslands and woodlands. However, many ecologists use the term when applied to habitats directly built by man such as railway lines or colliery spoil.

For instance, Kopecky and Hejny (1974) wrote of a new approach to the classification of anthropogenic plant communities in Bohemia. Sukopp (1990) researched the vegetation colonisation of Berlin and Jochimsen (2001) studied vegetation development on mine spoil. Other German ecologists have written articles on their urban flora such as Dettmar (1992) and Mucina *et al* (1993).

In America, synanthropic communities have also been studied. For example Lund (1974) analysed the urban plant communities of Atlanta, Kimmerer (1984) described the vegetation development on abandoned lead and zinc mines in Wisconsin and Crowe (1979) studied weed assemblages of vacant urban lots in Chicago. In Australia, Bell (2001) investigated into native ecosystem establishment on disused mines.

In Britain, there are few ecologists who have published work relating to urban or synanthropic community development. Hepburn (1942) described the plant assemblages of the Barnack stone quarries. A study of the plant colonisation of lime beds in Cheshire, dumping grounds for waste from the salt industry, was undertaken by Lee & Greenwood (1976). Silverside (1977) studied the phytosociology of British arable weeds and related communities for his PhD. Shaw (1992) published a paper describing the plant colonisation and long-term plant communities of pulverised fuel ash (PFA).

Among the synanthropic communities, railways have long attracted European botanists. In Sweden, Kreuzpointner (1876) and Holler (1883) published reports on the railway flora. In Latvia, Lehmann (1895) published an account of railway plants he had noted. Repp (1958) and Kreh (1960) both studied the typical railway plants of Germany. Repp identified distinct plant assemblages according to the railway ballast type. However, more common at that time was the approach of listing railway plants but not classifying them into communities.

Other countries followed suit; Almquist (1957) published a history of Sweden's railway flora. Pedersen (1966) published a similar paper in Denmark. Mikkola (1966), Suominen (1969) and Niemi (1969) all studied Finnish railway plants, Lejmbach *et al* (1965) researched Polish coastal railway lines and Lienenbecker and Raabe (1981) described the vegetation of railway lines in the Netherlands. In America, Muehlenbach (1979) published an extensive flora of railroad tracks in the St Louis area of Missouri, which he researched for 17 years.

There have been a number of continental studies on the phytosociology of railway plants such as Knapp (1961) and Gutte (1972) who both used the Braun-Blanquet methodology to describe railway plant communities in the Netherlands and Germany respectively. Brandes (1979, 1983) studied in detail German railway plant assemblages. A handful of ecologists have specifically studied railway sidings, which are often floristically richer than the main tracks. Bonte (1930) looked at the effect of war on the flora of German railway sidings and Suominen (1969) studied the vegetation of Finnish railway sidings. Hiller (2000) studied the soil characteristics of an abandoned shunting yard in the Ruhr area of Germany.

Compared to this research, British ecologists have produced few papers. Dony (1955) published an account of the Bedfordshire railway flora and followed this up with explaining the problems of working with railway plants (Dony, 1975). Messenger (1969) produced a Railway Flora of Rutland. In Sargent’s study (1984) only the railway embankments were studied on live railway lines and the plant communities were described with affinities to European plant communities. In a rare study of a disused railway line prior to it being converted to long-distance cycle track, Wright and Wheater (1993) surveyed the vegetation on a disused line in Derbyshire, England and identified communities such as *Molinio-Arrhenatheretea* grassland from the ballast and *Arrhenathereto-Rosetum* woodland on the embankments.

Railways present an interesting combination of water-stressed habitats and unusual substrates. In addition, their linear nature allows the study of plant colonisation to be easily made. Moreover, unlike roads, which are developments of early man-made routes, railways present completely new ground which is then open to colonizing plants. Finally, the relatively easily accessible documentation associated with the history of each railway (i.e. opening, closure and management practices) allows wider ecological questions, such as the timing of colonisation, to be investigated. Given that railways were constructed in a similar manner throughout Europe, it is notable that they support different plant communities in different locations at the national and local scale. Thus they make a suitable subject for phytosociological study.

This brief review has identified a key gap in British phytosociology; the description and understanding of ruderal communities. Moreover the opportunities presented by railway lines (particularly disused routes) have been largely ignored by British ecologists in contrast to work done elsewhere, notably on the continent.

The aims of this study are outlined below and are based on the investigation of the range of plant communities found on disused railway lines in Britain. The study will use both the European approach (Br-Bl methodology) and the British approach (NVC methodology). There will also be a study of the differences between the plant communities found using statistical tests.

Aims

1) National Vegetation Classification - Chapter 2 aims to sample disused railway lines using the NVC methodology and to attempt to place the plant communities found into existing NVC communities, comparing the grassland, woodland, maritime and scrub communities as well as the open vegetation communities. A further aim is to identify any communities which do not readily fall into an existing NVC category and to name these new vegetation communities.
2) The continental approach to phytosociologiy - Chapter 3 will utilise a similar approach to Chapter 2 but using Br-Bl methods of analysis. Due to the difficulties with directly comparing plant communities found in the UK to those found on the continent, Chapter 3 will aim to statistically test the plant

communities found based on floristic data only, as in the original Br-Bl methods.

3) Chapter 4 will investigate the factors influencing community composition within the sample set. An attempt will be made to understand the factors influencing community composition on the railway lines, using species composition against time since abandonment, climate and soil factors such as heavy metal content. The results of this should help to understand whether succession is predictable or random on synanthropic sites.
4) Chapter 5 will summarise the findings of the entire project and address the three aims above. The conservation value of disused railway lines will be assessed in Chapter 5 based upon species assemblage.

CHAPTER 2. NATIONAL VEGETATION CLASSIFICATION

2.1 INTRODUCTION

British Plant Communities (Rodwell, 1995-2000), known as the National Vegetation Classification (NVC), is the standard description of British vegetation and is widely adopted by government bodies, NGOs and professional and amateur ecologists. In addition to simply classifying vegetation, the NVC has been used to identify sites of conservation significance (e.g. the Severn Valley Grassland MG5s) and to understand the inter-relationship of communities (Averis *et al*, 2004). The NVC has also been used in a variety of wider ecological contexts. For example to assess the impact of hydrological change (Large *et al* 2007), the suitability of wet grassland for restoration (Hughes *et al*, 2005) and the potential for classifying beetle assemblages (Blake *et al*, 2003).

Despite this widespread usage there are several gaps in the work. This is highlighted by a consideration of the depth of coverage of the various sections. For the woodlands and scrub (vol. 1), heaths and mires (vol. 2) and grasslands (vol. 3), the NVC communities described are supported by extensive literature. For example W8 *Fraxinus excelsior–Acer campestre–Mercurialis perennis* woodland has 36 pages summarizing ecological research into this community and incorporates 59 references, the mire community M19 *Calluna vulgaris–Eriophorum vaginatum* blanket mire has nearly 12 pages of research described (45 references) and the calcareous grassland community CG2 *Festuca ovina–Avenula pratensis* grassland has 17 pages of research devoted to it (66 references).

By comparison the coverage of ruderal NVC communities (identified as open vegetation (OV), Volume 5) is much less comprehensive reflecting a lack of prior research in these communities. The 42 communities described fall into one of eight categories (arable weed and track-side communities of less fertile acid soils; arable weed and wasteland communities of fertile soils; arable weed communities of light limey soils; gateways, tracksides and courtyards; tall-herb weed communities; inundation communities; dwarf-rush communities of ephemeral ponds and crevice, scree and spoil vegetation). The 42 OV communities listed typically have two pages per community with a total of 94 references covering the whole OV section. There is little coverage of plant communities of synanthropic (man-made) habitats (e.g. railway lines, tar macadam roads, disused buildings and their associated hard standing).

These deficiencies were recognised in a follow-up report (Rodwell *et al*, 2000) and in the text of the NVC volumes. For example, in the general introduction to each volume, Rodwell states that the work was never intended to be a last word on the classification of British Plant Communities and could offer little more than a first approximation. In the introduction to open vegetation communities, Rodwell *et al* (2000) recognises that vegetation of disturbed or colonizing habitats is poorly covered and identifies the lack of typical urban waste ground communities such as *Reynoutria japonica* and *Buddleja* ssp.

This is reflected in the few studies carried out on British ruderal communities. For example, Lee & Greenwood (1976) studied the plant colonisation of lime beds in Cheshire, dumping grounds for waste from the salt industry. Silverside (1977) studied the phytosociology of British arable weeds and related communities and Shaw (1992) described the plant colonisation and long-term plant communities of pulverised fuel ash (PFA). Indeed some OV communities (such as OV6 *Cerastium glomeratum-Fumaria muralis* ssp. *boraei* community and OV10 *Poa annua–Senecio vulgaris* community) are allied to previous British phytosociology studies.

Even fewer British studies exist that investigate railway communities. Dony (1955) published an account of the Bedfordshire railway flora whilst Messenger (1969) did the same in Rutland. Sargent (1984) studied the railway embankments of live railway lines. Only one paper has been located which describes the vegetation on a disused Derbyshire railway line (Wright and Wheater, 1993).

The gaps within the NVC in terms of synanthropic vegetation communities reflect the lack of described ruderal communities within Britain. This chapter intends to address this gap. Disused railways offer an excellent habitat to sample due to their known history, linear habit and homogenous structure. Moreover, there are disused railways throughout Britain.

2.2 METHODS

2.2.1 Site selection

Sites were chosen for the presence of disused track with the rails *in situ*, and therefore ballast also still intact. The railways also had to possess vegetation so therefore had to have been abandoned for a minimum amount of time, usually two years. The vegetation needed to support mainly ruderal plant species and therefore, was generally in the early stages of succession; disused lines which were heavily wooded or supported significant coverage of scrub were not sampled (for example, sites dominated by *Rubus fruticosus* agg. were often impenetrable so were not sampled). Moreover, heavily wooded sites with rails *in situ* were rare. Sites were also chosen for convenience of access, safety and initial broad geographic spread although this was tempered by availability. Many of the disused lines were located in ex-industrial areas with little pressure for development on the land. Others were rural routes which served now defunct collieries or power stations. The locations were selected by firstly finding disused railways (Baker 2004, 2010) and OS paper maps. Aerial photography via Google earth and internet searches were then used to determine whether track was still *in situ*. If a disused track was very close to a live line it was not visited for health and safety reasons. It was the intention to obtain approximately 200 samples. This is a larger sample size than five of the eight groups of OV communities and comparable to the other three OV communities described by Rodwell (2000). Details of sites surveyed are listed in Table 2.1 below.

2.2.2 Sampling

At each site an approximately homogenous vegetation type was identified by eye and surveyed using up to 10 relevés. The number of relevés at each site was restricted by the extent of the community present. Each relevé was 10 metres long which measured out to approximately 13-14 sleepers. The width was always the distance between the two metal rails and only standard gauge railways were sampled (standard gauge being 4ft 8inches). Therefore, each relevé was approximately 1.4 metres x 10 metres. This followed the approach of Rodwell (1991) who advocated used 10 metre strips for sampling linear habitats such as stream edges and walls.

A field-recording sheet was created to input the raw data during the surveys (see Figure 2.1) which included space for environmental data and a sketch of the railway line. The field-recording sheet was created using aspects of the NVC recording sheet.

At each site, each plant was identified within the relevé. In general, the percentage cover of each plant was recorded, to enable subsequent MAVIS analysis. For the NVC tables, the percentage covers were converted into NVC Domin scores:

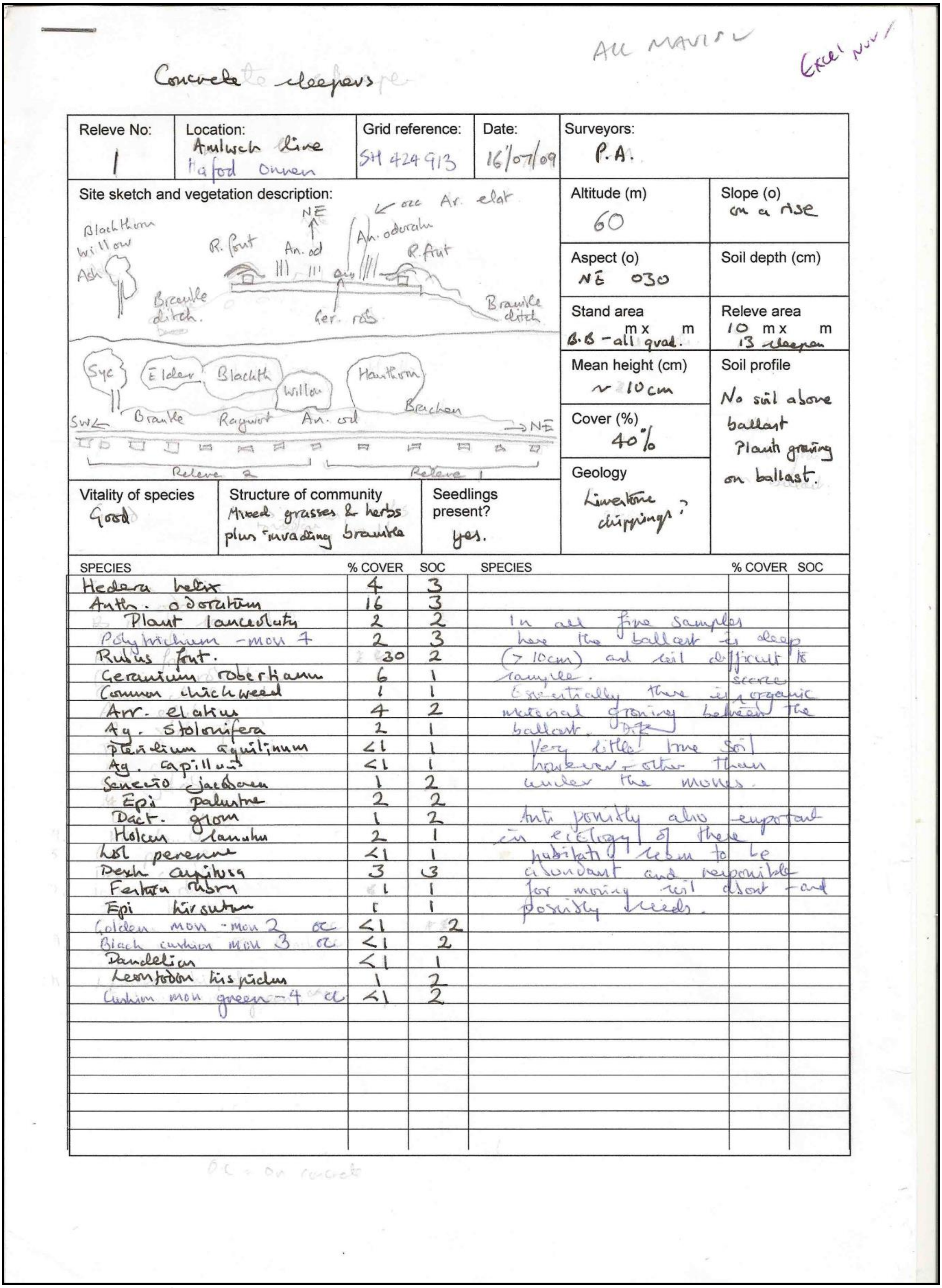
NVC Domin Scores	
10	**Cover of 91-100%**
9	**76-90%**
8	**51-75%**
7	**34-50%**
6	**26-33%**
5	**11-25%**
4	**4-10%**

3 with many individuals

2 with several individuals

1 with few individuals

In all cases, if plants, particularly non-vascular plants, could not be identified in the field then a small sample of the plant was collected for subsequent identification (i.e. with a microscope and relevant keys). Vascular plants were named following Stace (2010) and bryophytes using Smith (2004). The NVC community names (Rodwell, 1991-2000) were followed despite some including species names that have since been updated. An asterix in the results tables indicates where a name is new which does not correspond to the NVC species name. Microspecies were identified only to the aggregate level. In some cases, it was not possible to identify plants beyond genus due to their recent germination and small size. These are included within the NVC tables but are not included within the species totals.



All MAVIS ✓ Excel ✓

Concrete sleepers

Releve No:	Location:	Grid reference:	Date:	Surveyors:
1	Amlwch line Hafod Onnen	SH 424 913	16/07/09	P.A.

Site sketch and vegetation description:

Altitude (m)	60
Slope (o)	on a rise
Aspect (o)	NE 030
Soil depth (cm)	
Stand area m x m	B.B – all quad.
Releve area m x m	10 m x 13 sleepers
Mean height (cm)	~ 10 cm
Cover (%)	40%
Soil profile	No soil above ballast Plants growing on ballast.
Geology	Limestone chippings?

Vitality of species	Structure of community	Seedlings present?
Good	Mixed grasses & herbs plus invading bramble	yes.

SPECIES	% COVER	SOC
Hedera helix	4	3
Anth. odoratum	16	3
Plant lanceolata	2	2
Polytrichum – moss 7	2	3
Rubus frut.	30	2
Geranium robertianum	6	1
Common chickweed	1	1
Arr. elatius	4	2
Ag. stolonifera	2	1
Pteridium aquilinum	<1	1
Ag. capillaris	<1	1
Senecio jacobaea	1	2
Epi palustre	2	2
Dact. glom	1	2
Holcus lanatus	2	1
Lol perenne	<1	1
Desch caespitosa	3	3
Festuca rubra	1	1
Epi hirsutum	1	1
Golden moss – moss 2 oc	<1	2
Black cushion moss 3 oc	<1	2
Dandelion	<1	1
Leontodon hispidus	1	2
Cushion moss green – 4 oc	<1	2

In all five samples here the ballast is deep (> 10cm) and soil difficult to sample. Essentially there is scarce organic material growing between the ballast. Very little true soil however – other than under the mosses.

Ants possibly also important in ecology of these habitats seem to be abundant and responsible for moving soil about – and possibly seeds.

OC = on concrete

Figure 2.1 – Relevé recording sheet

176 relevés were taken from a total of 35 sites from 22 different railway lines (see Table 2.1).

TABLE 2.1 LIST OF RAILWAY LINE SITES SURVEYED				
SITE	**GRID REFERENCE**	**VICE-COUNTY**	**NO OF RELEVES**	**DATE SURVEYED**
Amlwch	SH 424913	52	5	16/07/2009
Appleby Cutting	NY 694200	69	4	13/07/2009
Appleby Embankment	NY 696195	69	4	13/07/2009
Appleby Wet	NY 694199	69	3	13/07/2009
Blaenau Ffestiniog Cutting	SH 705441	48	6	16/09/2009
Blaenau Ffestiniog Embankment	SH 707439	48	5	16/09/2009
Blaenau Ffestiniog Open	SH 704443	48	3	16/09/2009
Cambridge	TL 428639	29	5	23/08/2004
Carrington	SJ 753903	58	10	04/05/2007
Fleetwood North	SD 328457	60	5	07/07/2009
Fleetwood South	SD 342428	60	5	07/07/2009
Gobowen – Oswestry	SJ300313	40	5	17/07/2009
Golborne Ash	SJ 603993	59	3	03/08/2009
Golborne North	SJ 602991	59	5	03/08/2009
Golborne Sidings	SJ 603989	59	6	04/08/2004
Golborne South	SJ 601988	59	5	03/08/2009
Histon – St. Ives East	TL 397681	29	3	21/07/2007
Histon – St. Ives West	TL 363694	29	5	21/07/2007
Leek – Cauldon Quarry	SK 022538	39	10	12/05/2005
Leek – Cauldon Quarry Wooded	SJ 996545	39	3	12/05/2005
Leek – Stoke	SJ 939538	39	6	04/05/2005
Newport – Ebbw Vale	ST 210965	41	3	22/06/2007
Oswestry North Embankment	SJ 297302	40	5	17/07/2009
Runcorn Docks	SJ 499823	58	10	23/07/2009
St. Helens Acid Works	SJ 527938	58	5	29/07/2004
St. Helens Canal North	SJ 515950	59	5	06/07/2009
St. Helens Canal South	SJ 517949	59	5	06/07/2009
St. Helens Link	SJ 527939	58	4	21/06/2004
Staveley North	SK 440741	57	5	22/08/2009
Staveley South	SK 442739	57	5	22/08/2009
Trecwn East	SM 963324	45	3	10/09/2010
Trecwn West	SM 956320	45	5	10/09/2010
Wirksworth Quarry	SK 288545	57	3	18/07/2004
Woodthorpe Colliery	SK 459744	57	5	13/08/2009
Woodthorpe Colliery Junction	SK 456742	57	5	13/08/2009

2.2.3 NVC Analysis

Once each site had been sampled, floristic tables were produced from the botanical data. The frequency of each species was calculated and given a Roman numeral value between **I** and **V**; **I** = occurs between 1 and 20% of samples, **II** = 21-40%, **III** = 41-60%, **IV** = 61-80% and **V** = found in between 81-100% of quadrats sampled. Constant species were identified which form the backbone of the community. A constant species is a species which occurs in 61 to 100% of the quadrats, identified by the Roman numerals IV and V. A frequency of III is classed as a common or frequent species, II is classed as an occasional species and I as a scarce species.

Following the production of the NVC tables and the identification of the constant species, each community was analysed using three approaches; the MAVIS similarity programme, multivariate analysis and keying out using the NVC books with associated reading of the relevant literature. Each table was analysed using the Modular Analysis of Vegetation Information System (MAVIS) software (CEH). MAVIS analyses the data and attempts to classify each site into an NVC community. MAVIS works by computing a similarity co-efficient for each NVC community based on Sorenson's Similarity Co-efficient. MAVIS does not take into account the Domin scores of each species within each community. It is based only on shared presence of a species.

Correspondence Analysis (CA) was also used to analyse the communities. All of the communities were inputted to a MultiVariate Statistical Package (MVSP) programme (Kovach, Version 3) along with four NVC communities, chosen because of their frequency within the MAVIS results or by keying out the communities. Correspondence Analysis (CA) was chosen within MVSP.

TWINSPAN analysis was undertaken with default settings and the cut levels are 2 and 5 (as in Lockton & Whild, 2014). The mean and standard deviation of Ellenberg indicator values for Light, Werness, pH and Fertlity were calculated (Ellenberg ref) as were the man and standard deviation for CSR values (Grime *et al*, 1988) for the end groups identified by TWINSPAN.

In addition to MAVIS, CA and TWINSPAN, each site's NVC table was keyed out by hand using the published NVC Volumes 1 to 5. Once keyed out the relevant chapters were read carefully and a detailed comparison between each published NVC table and each sites NVC table was made. Comparison against the known distribution of each published NVC community and their habitat description and physiognomy was also undertaken.

Following this analysis, a decision was then made to allocate an NVC category for each railway community or decide that no NVC community could be allocated.

2.3 RESULTS

2.3.1 Correspondence Analysis (CA)

The results reveal different community composition between sites (see Figure 2.2). This is reflected in the CA result that shows a broad scatter of results with some communities close to those published. The strengths of these affinities are detailed within the account of each site below. Three of the four published communities are located centrally and relatively closely (OV23, MG1 and W24). The fourth community (OV38) is slightly more distant. All of the published communities are separated by the first axis.

Twinspan identified seven end groups in the stand analysis (Groups 1, 000, 001, 011, 0101, 01000 and 01001 - see Figure 2.3), with up to four indicator species in each group. The full data is included in the appendix. Arrhenatherum elatius appears as an indicator species in two groups (Group 1 and Group 01001). In Group 1 it is the sole indicator species and is found with preferential species including shrubs and scrub (*Acer pseudoplatanus*, *Rubus fruticosus* agg., *Calluna vulgaris*, *Ulex gallii*), grasses (*Holcus lanatus*) and large forbs (*Hypericum tetrapterum* and *Angelica sylvestris*). In Group 01001, *Arrhenatherum elatius* is identified as an indicator species along with *Epilobium montanum*, *Rubus fruticosus* agg., and *Brachythecium rutabulum*. Preferential species in this group includes the shrub *Buddleja davidii*, grasses (*Elytrigia repens*, *Poa pratensis*) and forbs (*Epilobium ciliatum*).

The Ellenberg indicator table values show little simple separation between groups, as does the CSR data (Table 2.2). The full TWINSPAN data set is included in Appendix 4. All groups are comprised of mainly competitors or stress tolerators. The two groups with *Arrhenatherum elatius* (1 and 01001), occupy the higher fertility end, a range of pH, at the higher end of the wetness scale and a range of light values. Both have comparable values of competitive species and stress tolerators but Group 1 has a much higher ruderal value than Group 01001. Indeed these reflect the highest and lowest values of all groups.

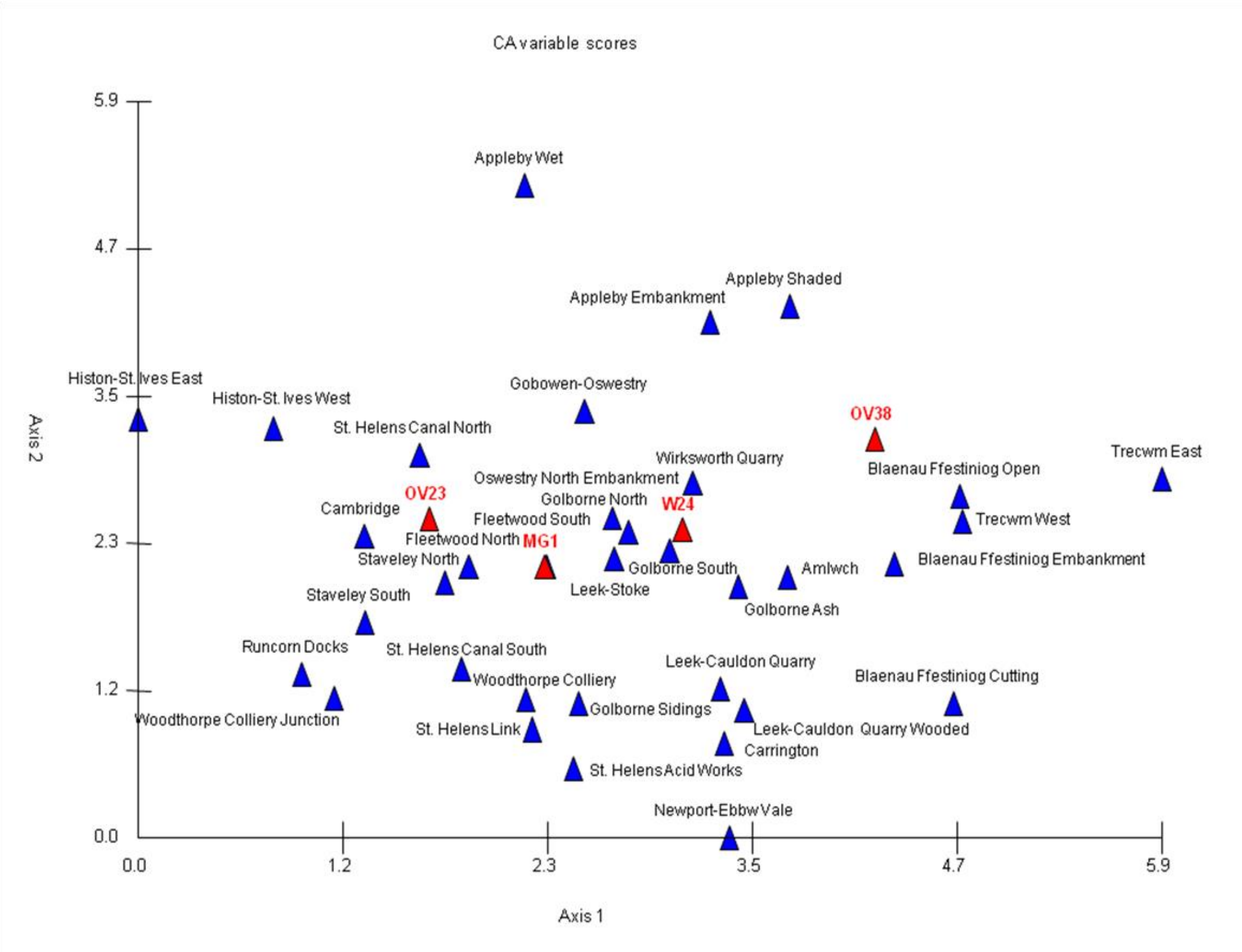


Figure 2.2 – CA scatter plot based on Domin scores for all sites

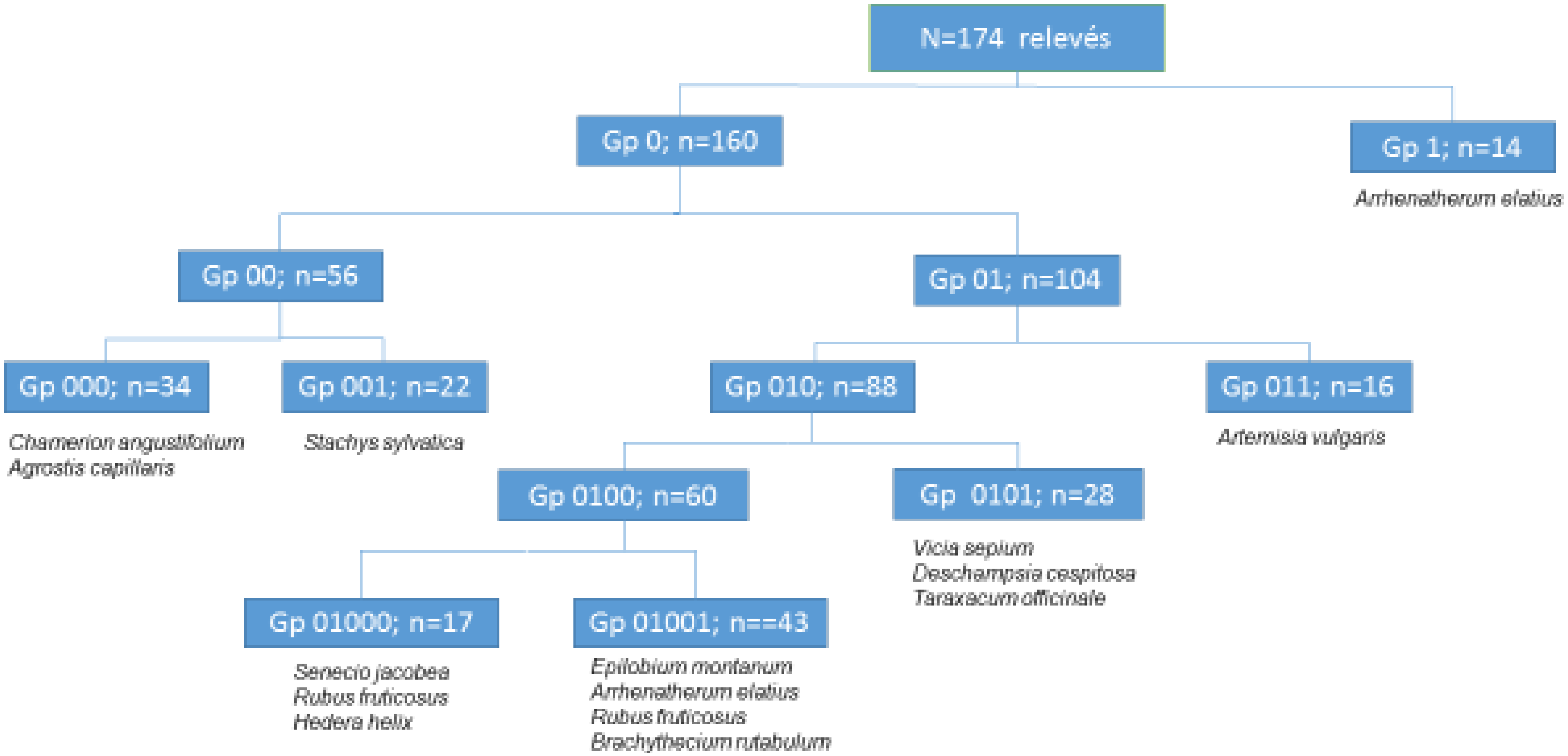


Figure 2.3 Twinspan analysis of 174 relevés with a total of 273 species

TABLE 2.2 FULL ECOLOGICAL DATA SET									
Group	n		Light	Wetness	pH	Fertility	C	S	R
1	14	**Mean**	**6.39**	**5.89**	**5.99**	**5.61**	**2.49**	**2.24**	**3.10**
		st dev	0.40	0.66	0.18	0.40	0.39	0.26	0.27
000	34	**Mean**	**6.94**	**5.13**	**6.27**	**5.28**	**2.82**	**2.14**	**2.73**
		SD	0.26	0.26	0.27	0.37	0.31	0.19	0.18
001	22	**Mean**	**6.92**	**5.63**	**6.47**	**5.61**	**3.08**	**2.08**	**2.55**
		SD	0.15	0.46	0.27	0.47	0.41	0.18	0.30
011	16	**Mean**	**7.06**	**4.93**	**6.49**	**5.23**	**2.70**	**2.16**	**2.93**
		SD	0.27	0.27	0.19	0.45	0.29	0.13	0.22
0101	28	**Mean**	**6.93**	**5.36**	**6.13**	**5.19**	**3.06**	**2.32**	**2.69**
		SD	0.20	0.20	0.23	0.38	0.29	0.26	0.33
01000	17	**Mean**	**6.54**	**5.54**	**5.84**	**5.02**	**3.09**	**2.42**	**2.47**
		SD	0.30	0.39	0.52	0.53	0.24	0.24	0.29
01001	43	**Mean**	**6.76**	**5.48**	**6.16**	**5.52**	**3.42**	**2.10**	**2.29**
		SD	0.44	0.39	0.49	0.65	0.43	0.43	0.40

2.3.2 NVC Analysis

The following pages show the NVC tables for each community sampled and a discussion of the NVC result from MAVIS and from comparing the existing NVC tables in each volume. Table 2.38 gives an overview of the results from each site.

2.3.2.1 Amlwch

TABLE 2.3 AMLWCH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Hedera helix	4	4	4	4	2	**V**
Anthoxanthum odoratum	5	5	6	5	5	**V**
Plantago lanceolata	2	1	2	1	5	**V**
***Rubus fruticosus* agg.**	6	5	4	4	4	**V**
Arrhenatherum elatius	4	2	2	2	1	**V**
Senecio jacobaea	1	1	1	1	1	**V**
Dactylis glomerata	1	2	4	4	1	**V**
Festuca rubra	1	1	4	1	1	**V**
Polytrichum commune* var. *commune	2		1	4	4	**IV**
Agrostis capillaris	1	5		4	4	**IV**
Holcus lanatus	2	4	4	2		**IV**
Geranium robertianum	4	1	1			**III**
Brachythecium rutabulum	1		1		4	**III**
Schistidium crassipilum	1	2			1	**III**
Atrichum undulatum		1	4	4		**III**
Linaria vulgaris			1	1	1	**III**
Campylopus introflexus			1	4	4	**III**
Agrostis stolonifera	2			1		**II**
Lolium perenne	1		1			**II**
Deschampsia cespitosa	3				1	**II**
Leontodon hispidus	1	1				**II**
Bryum capillare	1	1				**II**
Hieraceum sp.				1	4	**II**
Stellaria media	1					**I**
Pteridium aquilinum	1					**I**
Epilobium palustre	2					**I**
Epilobium hirsutum	1					**I**
Taraxacum officinale agg.	1					**I**
Epilobium parviflorum		1				**I**
Veronica officinalis		1				**I**
Ceratodon purpureus				2		**I**
Carex flacca				1		**I**
Lotus corniculatus				1		**I**
Equisetum arvense					1	**I**
Rumex acetosa					1	**I**
Epilobium montanum					1	**I**

TOTAL SPECIES: 36	24	17	16	19	19	
Top four MAVIS results:	FIT					
MG9b	48.3					
MG1a	43.8					
MG9	42.0					
MG1e	41.7					

The Amlwch line was situated on relatively flat ground and was surrounded by farmland. The community was mainly grass species with some low-growing herbaceous species and Bramble encroaching across the track. The vegetation cover was 50% on average. A total of 36 species were recorded. Eleven species were classed as constants. These included *Hedera helix*, *Anthoxanthum odoratum* and *Polytrichum commune* var. *commune*. Six of the eleven constants were grass species.

The CA analysis shows that Amlwch plot is closer to W24 than the other three NVC communities. This is not borne out by the species present at this site.

The top MAVIS result for Amlwch was MG9b *Holcus lanatus–Deschampsia cespitosa* grassland *Arrhenatherum elatius* sub-community. MG9 is a community of rank, tussocky grasses typical of permanently moist or periodically inundated neutral soils (Rodwell, 1994). The constants within the Amlwch community matched some of the constants within MG9b. However, the Amlwch community is free-draining and MG9 is a marshy grassland community so MG9 is discounted. MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community is a better match, MG1 being a community typical of well-drained unmanaged land and for the fact that *Holcus lanatus* was not recorded from within every quadrat at Amlwch albeit still attaining a constant status. The number of constant grass species also pushes this community towards MG1a. MG1 was the second and fourth result in MAVIS. However, the Amlwch community does not support the large Umbellifer species that form a constituent of MG1, probably because this community has developed from a pioneer ruderal community, rather than an unmanaged grassland community with more established soil. The CA analysis also shows that Amlwch is not close to MG1. **Amlwch is classed as having elements of MG1 but lacking the Umbellifer species.**

2.3.2.2 Appleby Embankment

TABLE 2.4 APPLEBY EMBANKMENT					
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**F**
Barbula convoluta	4	2	1	4	**V**
Schistidium crassipilum	4	4	4	4	**V**
Urtica dioica	1	1	1	1	**V**
Epilobium montanum	1	1	2	1	**V**
Lolium perenne	1	4	4	4	**V**
Cardamine hirsuta	1	1	1	1	**V**
Schistidium apocarpum s.s.	4	3	4	2	**V**
Brachythecium rutabulum	1	1	2	2	**V**
Arabidopsis thaliana	1	1		1	**IV**
Lathyrus pratensis	1	1	1		**IV**
Leucanthemum vulgare	1	1	1		**IV**
Ceratodon purpureus	1	1	4		**IV**
Sonchus oleraceus	1		1	1	**IV**
Kindbergia praelonga	1	2	4		**IV**
Festuca rubra		4	4	2	**IV**
Dactylis glomerata	1		2		**III**
Agrostis capillaris	1	1			**III**
Myosotis discolor		1	1		**III**
Scorzoneroides autumnalis		1		1	**III**
Holcus lanatus		2		1	**III**
*Galium album** (*Galium mollugo*)		1	1		**III**
Equisetum arvense		4	4		**III**
Deschampsia cespitosa		2		4	**III**
Myosotis arvensis			3	2	**III**
Geum urbanum	1				**II**
Fraxinus excelsior (sap)	1				**II**
Grimmia pulvinata		1			**II**
Calliergonella cuspidata		1			**II**
Tortula muralis		1			**II**
Hypochaeris radicata		1			**II**
Glechoma hederacea		1			**II**
Geranium robertianum			4		**II**
Poa pratensis			4		**II**
Lapsana communis			1		**II**
Sagina procumbens			1		**II**
Senecio vulgaris				1	**II**
TOTAL SPECIES: 36	**18**	**26**	**23**	**16**	
Top four MAVIS results:	**FIT**				
W24b	**36.9**				
W24	**34.6**				
MG6	**32.7**				
OV23	**31.8**				

The Appleby Embankment site was situated on a low embankment, surrounded by permanent pasture. The ballast was open with a low coverage of vegetation (on average 30% cover). The community comprised mainly low-growing herbaceous species with many bryophytes. A total of 36 species were recorded from here with fifteen constant species. Constants included six species of bryophyte along with *Epilobium montanum*, *Urtica dioica*, *Arabidopsis thaliana* and *Lathyrus pratensis.*

The CA shows the Appleby Embankment plot as distant from any of the NVC communities. The top MAVIS result for Appleby Embankment was W24b *Rubus fruticosus–Holcus lanatus* underscrub *Arrhenatherum elatius–Heracleum sphondylium* sub-community. While this community is typical of abandoned and neglected ground (Rodwell, 1991), the presence of only two W24 constant species at the site (*Urtica dioica* and *Festuca rubra*), in addition to the lack of *Rubus fruticosus* agg., led to this community allocation being rejected. Other MAVIS results can also be eliminated. MG6 *Lolium perenne–Cynosurus cristatus* grassland occurs on free-draining ground and can be found within the uplands as long as lime is added to maintain the *Lolium perenne.* However, *Cynosurus cristatus,* a key element of the MG6 community is absent OV23 *Lolium perenne–Dactylis glomerata* community was the fourth MAVIS result. This is a community of neglected but resown habitats, with a closed sward. The Appleby community was an open community with very little *Dactylis glomerata.* **Therefore, the community at Appleby Embankment cannot be matched with any existing NVC community.**

2.3.2.3 Appleby Shaded

TABLE 2.5 APPLEBY SHADED					
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**F**
Epilobium montanum	2	2	1	4	**V**
Schistidium crassipilum	4	5	5	4	**V**
Schistidium apocarpum s.s.	4	4	4	2	**V**
Geranium robertianum	4	2	1	1	**V**
Cardamine flexuosa	2	5	4	4	**V**
Urtica dioica	1	1	1	1	**V**
Sonchus oleraceus	1		1	1	**IV**
Acer pseudoplatanus (sap)			1	1	**III**
Hypnum cupressiforme			1	1	**III**
Cardamine hirsuta	2				**II**
Hypericum pulchrum	1				**II**
Geum urbanum	1				**II**
Hypnum cupressiforme	1				**II**
Lolium perenne		1			**II**
Calliergonella cuspidata		1			**II**
Barbula convoluta		1			**II**
Rumex acetosa		1			**II**
Chamerion angustifolium		1			**II**
Leucanthemum vulgare		1			**II**
*Galium album** (*Galium mollugo*)		1			**II**
Epilobium parviflorum			1		**II**
Sagina procumbens				1	**II**
Lathyrus pratensis				1	**II**
Poa pratensis				2	**II**
Veronica beccabunga				1	**II**
Deschampsia cespitosa				1	**II**
Tussilago farfara				1	**II**
TOTAL SPECIES: 26	**11**	**13**	**10**	**15**	
Top four MAVIS results:	**FIT**				
OV27	**24.3**				
W24	**24.0**				
W24b	**23.7**				
MG1b	**23.0**				

The Appleby Shaded site was situated within a cutting with dense woodland on the slopes. It was a damp, shaded community. The vegetation was a mixture of low-growing herbaceous species, open ballast, minimal grass cover and six species of bryophyte. The vegetation cover over the ballast was low (average of 30%). A total of 26 species were recorded from here, eight of those were constants, including *Geranium robertianum*, *Sonchus oleraceus* and two species of bryophyte.

The CA shows the Appleby Shaded plot as distant from any NVC community. The top MAVIS result for Appleby Shaded was OV27 *Epilobium angustifolium* community, with W24 and W24b *Rubus fruticosus–Holcus lanatus* underscrub *Arrhenatherum elatius–Heracleum sphondylium* sub-community closely following. None of these communities fit the Appleby Shaded community due to the lack of matching species. For example, *Chamerion angustifolium*, *Rubus fruticosus* agg. or *Holcus lanatus* did not occur in any sample at this site. Similarly, the fourth MAVIS result of MG1 can be discounted due to the lack of *Arrhenatherum elatius* in the community. **The Appleby Shaded community cannot be placed within any existing NVC community.**

2.3.2.4 Appleby Wet

TABLE 2.6 APPLEBY WET				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Veronica beccabunga	4	2	1	**V**
Cardamine flexuosa	4	2	4	**V**
Urtica dioica	1	1	2	**V**
Epilobium montanum	1	2	1	**V**
Alliaria petiolata	1	1	1	**V**
Lolium perenne	1	1	2	**V**
Agrostis stolonifera	1	1	1	**V**
Stellaria media	1		1	**IV**
Sagina procumbens		2	5	**IV**
Poa annua		1	1	**IV**
Solanum dulcamara		1	1	**IV**
Chamerion angustifolium	1			**II**
Juncus articulatus	1			**II**
Epilobium palustre	1			**II**
Galium palustre	1			**II**
Holcus lanatus		1		**II**
Juncus bufonius		1		**II**
Galium aparine		1		**II**
Brachythecium rivulare		1		**II**
Geranium robertianum		1		**II**
Kindbergia praelonga		1		**II**
Tussilago farfara		1		**II**
Ranunculus bulbosus			1	**II**
Senecio jacobaea			1	**II**
Barbula convoluta			1	**II**
Ceratodon purpureus			1	**II**
Galium saxatile			1	**II**
Plantago major			1	**II**
Leucanthemum vulgare			1	**II**
Myosotis arvensis			1	**II**
Epilobium parviflorum			2	**II**
Arabidopsis thaliana			1	**II**
TOTAL SPECIES: 32	**12**	**17**	**21**	
Top four MAVIS results:	**FIT**			
OV10c	**33.8**			
OV10	**33.1**			
OV20b	**33.1**			
OV23	**32.7**			

The Appleby Wet site was situated within a cutting, with dense woodland and scrub on the slopes either side of the track. The community was a mixture of ruderal species and bryophytes with taller vegetation nearer to the rails. This section of track was more open than Appleby Shaded, with a less dense canopy shading the track. Vegetation cover was very low on the ballast with an average of 15% cover. A total of 32 species were recorded including eleven constants. Constants included *Veronica beccabunga*, *Alliaria petiolata* and *Solanum dulcamara*.

The CA shows the Appleby Wet plot as extremely distant from any of the four NVC communities. The top MAVIS result for the Appleby Wet site was OV10c *Poa annua–Senecio vulgaris* community *Agrostis stolonifera–Rumex crispus* sub-community. The NVC table for OV10c matched the constant *Poa annua* from the Appleby Wet community. However *Senecio vulgaris* was not present in this community and OV10 is typical of fertile habitats which are trampled or disturbed, so ecologically does not match this site. When comparing the tables, three constants were matched with OV20b *Poa annua–Sagina procumbens* community *Lolium perenne–Chamomilla suaveolens* sub-community (The constants being *Poa annua*, *Sagina procumbens* and *Lolium perenne*). OV20 is typically a crevice community, occurring within paving cracks and between cobbles; a hostile habitat with varying degrees of moisture throughout the year which only certain species can tolerate. It was also the third MAVIS fit. However, the ballast at Appleby Wet was dissimilar to the OV20 habitats and the species assemblage was completely different. OV23 *Lolium perenne-Dactylis glomerata* community was the fourth MAVIS result. *Dactylis glomerata* did not occur at Appleby Wet and OV23 is typically a closed sward community of fertile ground, Appleby Wet was an open community of infertile ballast. **None of these communities fitted the**

community present at Appleby Wet and no NVC community can be allocated.

2.3.2.5 Blaenau Ffestiniog Cutting

TABLE 2.7 BLAENAU FFESTINIOG CUTTING							
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**6**	**F**
Arrhenatherum elatius	4	5	4	1	1	4	**V**
***Fraxinus excelsior* (sap)**	5	5	5	6	7	7	**V**
Agrostis capillaris	1	1	1	1		1	**V**
Geranium robertianum	1	1	1	1		4	**V**
Epilobium ciliatum	1	1	1	1		1	**V**
Festuca rubra	5	4	1	1			**IV**
***Rubus fruticosus* agg.**	5	5	7			4	**IV**
Dactylis glomerata	1	1	2				**III**
Rhododendron ponticum	1	2	2				**III**
Senecio jacobaea			1	1		1	**III**
Quercus robur (sap)			2	1		1	**III**
Hypericum pulchrum	1			1			**II**
Viola riviniana	1			1			**II**
Teucrium scorodonia	1		1				**II**
Holcus lanatus	1	1					**II**
Crataegus monogyna	1				1		**II**
Leycesteria formosa	1		4				**II**
Plantago lanceolata		1	1				**II**
Dryopteris felix-femina		1				1	**II**
Peltigera sp.		1	1				**II**
Buddleja davidii			4	4			**II**
Hieraceum umbellatum	1						**I**
Taraxacum officinale agg.	1						**I**
Luzula campestre	1						**I**
Digitalis purpurea	1						**I**
Asplenium trichomanes		1					**I**
Agrostis stolonifera		1					**I**
Lotus corniculatus		1					**I**
Leylandii		1					**I**
Hypochaeris radicata		1					**I**
Heracleum sphondylium		1					**I**
Sonchus asper		1					**I**
Solidago canadensis			2				**I**
Luzula sylvatica				1			**I**
Chamerion angustifolium				1			**I**
Urtica dioica				1			**I**
Dryopteris felix-mas					1		**I**
Rhytidiadelphus squarrosus						4	**I**
Juncus effusus						1	**I**
TOTAL SPECIES: 39	**19**	**20**	**17**	**14**	**4**	**11**	
Top four MAVIS results:	**FIT**						
MG1a	**40.4**						
SD9a	**39.7**						
W24	**38.7**						
OV27	**36.8**						

The Blaenau Ffestiniog Cutting site was situated within a deep cutting. To the north was the bare slate cutting and to the south was a low mound covered in trees and shrubs. This was a sheltered and shaded site. The community comprised tall grass near to the rails with many Ash saplings scattered on the ballast. A number of non-native species were present albeit with low cover values. The vegetation covered more of the track than on the adjacent embankment site with an average of 70% cover. A total of 39 species were recorded. Seven species were recorded as constants including *Geranium robertianum*, *Fraxinus excelsior* and *Epilobium ciliatum*.

The CA shows the Blaenau Ffestiniog Cutting plot as very distant from any of the four NVC communities. The top MAVIS result from Blaenau Ffestiniog Cutting was MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community. This matches two constant species from the site: *Arrhenatherum elatius* and *Festuca rubra.* Comparison to the existing NVC tables shows that OV38 *Gymnocarpietum robertianae* community is a slightly better fit with three constants being matched; *Geranium robertianum*, *Arrhenatherum elatius* and *Festuca rubra.* However, *Gymnocarpium robertianum* was not present on this site. Moreover this is a Northern England limestone scree community. With ballast being granite this will give a calcifugous community, hence OV38 has been omitted from consideration. Likewise the second MAVIS result, SD9a *Ammophila arenaria–Arrhenatherum elatius* dune grassland typical sub-community can also be discounted due to it being a dune community and due to the lack of *Ammophila arenaria* on the site. OV27 *Epilobium angustifolium* community can be discounted due to the tiny amount of *Chamerion*

(Epilobium) angustifolium present on the site. W24 *Rubus fruticosus–Holcus lanatus* underscrub was the third MAVIS result and the site does have affinities with this NVC community. *Rubus fruticosus* agg. is a constant and records relatively high cover values in comparison with other species as does *Fraxinus excelsior* (as saplings). This moves the community away from MG1 as *Arrhenatherum elatius* has lower cover values. However, the combination of the other species present shows this community has elements of acid heath to it with species occurring such as *Rhododendron ponticum* and *Luzula sylvatica.* There are also a number of non-native species present such as *Leycesteria formosa* and *Buddleja davidii.* **Blaenau Ffestiniog Cutting has affinities to W24 but with acidic heath and non-native constituents.**

2.3.2.6 Blaenau Ffestiniog Embankment

TABLE 2.8 BLAENAU FFESTINIOG EMBANKMENT						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Arrhenatherum elatius	6	5	5	4	5	**V**
Agrostis capillaris	1	1	1	1	1	**V**
Hypnum cupressiforme	1	1	1	2	2	**V**
Festuca ovina	1	1	1	5		**IV**
Viola riviniana		1	1	1	1	**IV**
Dactylis glomerata	1			1	1	**III**
Epilobium ciliatum	1			1	1	**III**
Teucrium scorodonia		4		4	1	**III**
Geranium robertianum			1	1	1	**III**
Holcus lanatus	2				1	**II**
Festuca rubra		2	2			**II**
Hypericum pulchrum		1	1			**II**
Heracleum sphondylium			1		1	**II**
Rhytidiadelphus squarrosus	1					**I**
Calliergonella cuspidata	1					**I**
Calluna vulgaris	1					**I**
Stellaria media		1				**I**
Taraxacum officinale agg.				1		**I**
Senecio jacobaea				1		**I**
Digitalis purpurea				1		**I**
Fraxinus excelsior (sap)				1		**I**
Hieraceum umbellatum				1		**I**
Pilosella officinarum				1		**I**
Hypochaeris radicata				1		**I**
Plantago lanceolata				1		**I**
Epilobium parviflorum					1	**I**
TOTAL SPECIES: 26	**10**	**9**	**9**	**17**	**11**	
Top four MAVIS results:	**FIT**					
SD9a	**38.4**					
W23	**38.2**					
MG1a	**38.1**					
W24	**36.9**					

The Blaenau Ffestiniog Embankment site was situated on a slight embankment. The surrounding land was farmland and heathland. The ballast was open and the average vegetation cover was 40%. The site was dominated by *Arrhenatherum elatius* which tended to grow near to the rails. Low growing herbaceous species and bryophytes occurred sporadically on the ballast. A total of 26 species were recorded with five of these being constant species. Constants included *Hypnum cupressiforme* and *Festuca ovina.*

The CA shows the Blaenau Ffestiniog Embankment plot distant from any of the NVC communities but in line with some other sites which have affinities to MG1. The top MAVIS result from Blaenau Ffestiniog Embankment was SD9a *Ammophila arenaria–Arrhenatherum elatius* dune grassland typical sub-community. However, this community matched only *Arrhenatherum elatius* as a constant species and ecologically did not fit. The only woodland feature is the presence of *Fraxinus excelsior* saplings hence the W23 *Ulex europaeus-Rubus fruticosus* scrub community and W24 *Rubus fruticosus–Holcus lanatus* underscrub community designations are inappropriate. This is also reflected in the distance of the Blaenau Ffestiniog Embankment plot from the W24 plot on the CA plot. A closer match to an existing NVC community appeared to be CG10a *Festuca ovina–Agrostis capillaris–Thymus praecox* grassland *Trifolium repens–Luzula campestris* sub-community. This is a community of calcareous bedrock and coarse-textured superficial deposits. CG10a also matched three constants: *Festuca ovina*, *Agrostis capillaris* and *Viola riviniana.* However, CG10a does not fit the community due to it being typically a closed sward community that is heavily grazed and *Thymus praecox* does not occur at the Blaenau Ffestiniog Embankment site, probably due to the non-calcareous nature of the substrate. The assemblage here has affinities with MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community due to the dominance of *Arrhenatherum elatius* and the presence of other grasses such as *Agrostis capillaris* and *Dactylis glomerata.* However, it does lack other constituents of MG1a such as tall Umbellifers and the site supports an acid heath element to it with species occurring such as *Digitalis purpurea* and *Calluna vulgaris.* **This community has affinities to MG1 but cannot be placed within an existing MG1 sub-community.**

2.3.2.7 Blaenau Ffestiniog Open

TABLE 2.9 BLAENAU FFESTINIOG OPEN				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Molinia caerulea	7	6	7	**V**
***Rubus fruticosus* agg.**	4	5	2	**V**
Holcus lanatus	4	5	6	**V**
Brachythecium rutabulum	4	4	4	**V**
Senecio jacobaea	1	1	1	**V**
Epilobium ciliatum	1	1	2	**V**
***Fraxinus excelsior* (sap)**	4	4	4	**V**
Lolium perenne	2	2		**IV**
Agrostis capillaris	2	2		**IV**
Rhododendron ponticum	1	1		**IV**
Epilobium parviflorum	1		1	**IV**
Geranium robertianum		1	1	**IV**
***Betula pubescens* (sap)**		2	2	**IV**
Dryopteris felix-mas	1			**II**
Dryopteris felix-femina		1		**II**
Arrhenatherum elatius		1		**II**
Vaccinium myrtillus		1		**II**
Rhytidiadelphus squarrosus		3		**II**
Plantago lanceolata			1	**II**
Festuca rubra			2	**II**
Rumex acetosa			1	**II**
Juncus articulatus			1	**II**
Calluna vulgaris			1	**II**
TOTAL SPECIES: 23	**12**	**16**	**15**	
Top four MAVIS results:	**FIT**			
W23b	**30.7**			
MG6b	**29.4**			
MG9	**28.5**			
MG9b	**28.3**			

The Blaenau Ffestiniog Open site was situated within a shallow cutting. The track was more open to the light than the Blaenau Ffestiniog Cutting site. The site was wet, from run-off from the surrounding slate cutting and had elements of heath within the species assemblage. The community was a mixture of tall grass growing close to the rails, with single pioneer shrub species and Bramble encroaching across the ballast. Mean vegetation cover was 60%. A total of 23 species were recorded with thirteen of these being constants.

Constants included *Molina caerulea*, *Rhododendron ponticum*, *Brachythecium rutabulum* and *Epilobium parviflorum.*

The CA shows the Blaenau Ffestiniog Open plot close to OV38 *Gymnocarpietum robertianum-Arrhenatherum elatius* community. This can be discounted because OV38 is a community of limestone uplands. The top MAVIS result for Blaenau Ffestiniog Open was W23b *Ulex europaeus–Rubus fruticosus* scrub *Rumex acetosella* sub-community. The lack of *Ulex europaeus* means W23 does not match this community. The Blaenau Ffestiniog Open community supported *Molinia caerulea* as a constant species. *Molinia caerulea* features in the heathland communities, which is not reflected in other constituents of this community. MG6b *Lolium perenne-Cynosurus cristatus* grassland *Anthoxanthum odoratum* community was the second MAVIS result. However MG6 is a permanent pasture community with many grasses and no heathland characteristics. MG9 *Holcus lanatus-Deschampsia cespitosa* grasslands were also identified as matches by MAVIS. *Deschampsia cespitosa* did not occur at the site and MG9 is typically a closed and stable grassland sward of permanently moist soils. Thus MG9 does not match the Blaenau Ffestiniog Open community. **Due to the combination of heath species, tree saplings and calcifugous species, no existing NVC communities can be matched to this community.**

2.3.2.8 Cambridge

TABLE 2.10 CAMBRIDGE						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Achillea millefolium	7	7	5	5	7	**V**
Lolium perenne	5	7	5	7	5	**V**
Artemisia vulgaris	3	1	3	4	2	**V**
Arrhenatherum elatius	3	3	5	3	3	**V**
Trifolium campestre	5	1	2	3	2	**V**
Conyza canadensis	3	3	3	3	3	**V**
Senecio jacobaea	1	2	3	3	3	**V**
Festuca rubra	4	5	4	7	7	**V**
***Rubus fruticosus* agg.**	6	6	4	2		**IV**
Crepis capillaris	4	2	2	1		**IV**
Dactylis glomerata	4	3	5	3		**IV**
Calystegia sepium	3	1		3	3	**IV**
Poa pratensis		1	3	2	1	**IV**
Plantago lanceolata	1			3	3	**III**
Tragopogon pratensis	1		1		1	**III**
Sagina procumbens	3	3		1		**III**
Leucanthemum vulgare	1		2	3		**III**
Chamerion angustifolium		1	1		1	**III**
Taraxacum officinale			2	2	2	**III**
Scorzoneroides autumnalis			2	1	2	**III**
Deschampsia flexuosa	1	1				**II**
Nardus stricta	1	1				**II**
Aira caryophylla	1	1				**II**
Hypochaeris radicata		1		1		**II**
Rumex acetosa				3	1	**II**
Anisantha sterilis				1	1	**II**
Matricaria discoidea	1					**I**
Heracleum sphondylium	1					**I**
Hypericum perforatum	1					**I**
Stellaria media			2			**I**
Rosa canina agg.				1		**I**
Agrostis stolonifera				1		**I**
Elytrigia repens				4		**I**
Hedera helix				1		**I**
Cirsium arvense					1	**I**
Succisa pratensis					1	**I**
TOTAL SPECIES: 36	**22**	**19**	**18**	**25**	**19**	
Top four MAVIS results:	**FIT**					
MG1a	**42.6**					
OV23	**42.3**					
OV23d	**41.1**					
SD9a	**41.0**					

The Cambridge site was situated in an open aspect on level ground bordered by arable farmland. The line tended to exhibit tall vegetation near to the rails with shorted vegetation towards the centre of the track and patches of open ballast. A total of 36 species were recorded from this site and this included thirteen constant species. Constants included *Achillea millefolium* and *Arrhenatherum elatius* along with ruderal species such as *Conyza canadensis*, *Artemisia vulgaris* and *Calystegia sepium.* All constants exhibited low to medium cover.

The CA shows the Cambridge plot as being close to OV23 *Lolium perenne–Dactylis glomerata* community. The top MAVIS result for Cambridge was to MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community. Second best fit in MAVIS was OV23. Both of these communities have constant species which match some of the constants at Cambridge, for example, *Dactylis glomerata*, *Lolium perenne* and *Arrhenatherum elatius.* However, one constant at Cambridge was *Achillea millefolium* and this is a constant species in OV23d. The fourth match (SD9a *Ammophila arenaria–Arrhenatherum elatius* dune grassland typical sub-community) can be discounted as *Ammophila arenaria* is absent. **This community is classed as OV23d *Lolium perenne–Dactylis glomerata* community *Arrhenatherum elatius-Medicago lupulina* sub-community, given the number of ruderal species present.**

2.3.2.9 Carrington

TABLE 2.11 CARRINGTON											
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**F**
Hypnum cupressiforme	7	7	4	4	7	3	2	1	4	2	**V**
Arrhenatherum elatius	5	4	3	2	1	6	4	4	8	7	**V**
***Rubus fruticosus* agg.**	1	1	6	4	5	5	4	5	4	4	**V**
***Taraxacum officinale* agg.**	1	1	1	1	3	1	1	1	4		**V**
Festuca rubra	1	4		3	4	3	4		4	4	**IV**
Chamerion angustifolium	1	1	2	2	1		2	4		2	**IV**
Senecio jacobaea	4	1			1	1	3	1	1	1	**IV**
Agrostis capillaris	1	1	1	1				1	1		**III**
Betula pendula (sap)		5	1	2	4	1					**III**
Impatiens glandulifera			1			1	1	1	1	1	**III**
Epilobium hirsutum				1		1	3	2		4	**III**
Sorbus aucuparia (sap)	1	1		4	4						**II**
Heracleum sphondylium	1	1			1						**II**
Salix caprea (sap)		1	1	4							**II**
Sonchus asper		1		1				1			**II**
Geranium dissectum				1	1	1			2		**II**
Hypochaeris radicata				2	3		2				**II**
Betula pubescens (sap)					1	1		1			**II**
Lapsana communis	1										**I**
Plantago lanceolata	1										**I**
Convolvulus arvensis	5				1						**I**
Dactylis glomerata		1		1							**I**
Epilobium sp.		1									**I**
Viola canina agg.			1								**I**
Ribes sp.			1								**I**
Crataegus monogyna (sap)			1								**I**
Geum urbanum				4							**I**
Salix cinerea (sap)				1	1						**I**
Fraxinus excelsior (sap)				2	1						**I**
Quercus robur (sap)					2		1				**I**
Geranium robertianum					1						**I**
Scrophularia nodosa					2						**I**
Filipendula ulmaria					1	1					**I**
Cirsium arvense					1	1					**I**
Teucrium scorodonia						1					**I**
Lolium perenne						1					**I**
Ulota crispa agg.							2				**I**
Schistidium crassipilum							2				**I**
Hieraceum sp.								1			**I**
Galium aparine								2			**I**
Alnus glutinosa (sap)									4		**I**
Acer pseudoplatanus (sap)										1	**I**
TOTAL SPECIES: 42	**13**	**15**	**12**	**18**	**21**	**15**	**13**	**13**	**10**	**9**	
Top four MAVIS results:	**FIT**										
W24	**38.9**										
MG1a	**38.1**										
MG1	**36.7**										
MG1b	**36.6**										

The Carrington site was situated on a low embankment, surrounded by arable land. The vegetation covered, on average, 70% of the ballast. The community comprised tall grasses close to the rails with Bramble encroaching across the ballast and many ruderal species. A total of 42 species were recorded. This included seven constant species, including *Hypnum cupressiforme*, *Chamerion angustifolium*, *Taraxacum officinale* agg. and *Senecio jacobaea.* This community included many species of tree sapling such as *Alnus glutinosa*, *Quercus robur* and *Sorbus aucuparia.*

The CA shows the Carrington plot as equidistant between W24 *Rubus fruticosus-Holcus lanatus* underscrub and MG1 *Arrhenatherum elatius* grassland, albeit some distance from either. The top MAVIS result for Carrington was W24. This is due to *Rubus fruticosus* agg. being found in every relevé. Comparison with the published NVC tables shows that W24 matches three constant species with Carrington; *Rubus fruticosus* agg., *Arrhenatherum elatius* and *Taraxacum officinale* agg*.* The Carrington community also has elements of MG1 with *Arrhenatherum elatius* a constant species plus other grass species. Due to the constant *Chamerion (Epilobium) angustifolium*, the OV communities were analysed and OV27e *Epilobium angustifolium* community *Ammophila arenaria* sub-community also matches three constant species; *Chamerion angustifolium*, *Festuca rubra* and *Senecio jacobaea.* However, the Carrington community appears more akin to a grassland, with greater similarities to MG1 more so than W24, due to the number of grass species present and the presence of a tall Umbellifer

(*Heracleum sphondylium*). **Therefore, Carrington is classed as having affinities to MG1.**

2.3.2.10 Fleetwood North

TABLE 2.12 FLEETWOOD NORTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
***Rubus fruticosus* agg.**	5	5	4	5	4	**V**
***Taraxacum officinale* agg.**	2	1	2	2	1	**V**
Leucanthemum vulgare	4	5	4	4	4	**V**
Leontodon hispidus	4	2	4	4	2	**V**
Arrhenatherum elatius	4	3	3	1	2	**V**
Epilobium parviflorum	1	4	2	1	1	**V**
Senecio jacobaea	3	1	4	4		**IV**
Epilobium palustre	1	1		1	1	**IV**
Festuca ovina		4	1	1	2	**IV**
Potentilla reptans	1		4	2		**III**
Dactylis glomerata	1	1			1	**III**
Festuca rubra	5	8			2	**III**
Bromus hordeaceus	4	1			1	**III**
Hieraceum sp.	1			1	1	**III**
Vicia sativa	1	4	1			**III**
Ceratodon purpureus	1			1	1	**III**
Convolvulus arvensis		1	1	1		**III**
Vicia cracca	1	2				**II**
Geranium robertianum	1				4	**II**
Brachythecium rutabulum	4			4		**II**
Holcus lanatus	1	2				**II**
Sedum rupestre	2				4	**II**
Anisantha sterilis	2	1				**II**
Cladonia sp.	1				1	**II**
Plantago lanceolata	1			1		**II**
*Helminthotheca echioides** (*Picris*)	1	1				**II**
Myosotis discolor	1	1				**II**
Linum catharticum	1	1				**II**
Cirsium arvense		1	1			**II**
Epilobium montanum		1		2		**II**
Valeriana officinalis			4	5		**II**
Sonchus arvensis			1		2	**II**
Salix caprea (sap)	1					**I**
Achillea millefolium	1					**I**
Sonchus oleraceus	1					**I**
Lapsana communis	4					**I**
Daucus carota	3					**I**
Trifolium campestre	1					**I**
Bryum caespiticium	1					**I**
Centaurea nigra		1				**I**
Chamerion angustifolium		1				**I**
Bryum sp.		1				**I**
Cerastium fontanum		1				**I**
Crataegus monogyna (sap)		1				**I**
Rumex acetosa		1				**I**
Galium aparine		1				**I**
Campylopus introflexus				1		**I**
Geum urbanum				1		**I**

SPECIES/RELEVE	1	2	3	4	5	F
*Erigeron acris** (*Erigeron acer*)				1		I
Hypericum humifusum				1		I
TOTAL SPECIES: 50	**33**	**29**	**14**	**21**	**17**	
Top four MAVIS results:	**FIT**					
MG1a	**40.7**					
MG1b	**38.5**					
CG6	**38.2**					
MG1	**37.7**					

The Fleetwood North site was situated on flat ground, with a caravan park to the west and a reedbed to the east. The ballast was, on average, 60% covered in low-growing plants with taller grasses and Bramble close to the rails. A number of bryophyte species were present along with many species of grass. In total, 50 species were recorded, which included nine constants. These included *Leontodon hispidus*, *Festuca ovina* and *Leucanthemum vulgare*.

The CA shows the Fleetwood North plot as equidistant from MG1 *Arrhenatherum elatius* grassland and OV23 *Lolium perenne-Dactylis glomerata* community. The top MAVIS result for Fleetwood North was MG1a (*Festuca rubra* sub-community) with a high similarity. MG1 also came out in two of the other three MAVIS results. The community here does have affinities with MG1a due to the constant *Arrhenatherum elatius* and the presence of other grass species but lacks the tall Umbellifers. CG6 *Avenula pubescens* grassland, the third MAVIS result, can be discounted due to the lack of *Avenula pubescens* and the relative rarity of CG6 in the British Isles. *Leontodon hispidus* and *Festuca ovina* were constant species at Fleetwood North and three other calcareous grassland communities include these species as constants; CG2 *Festuca ovina–Avenula pratensis* grassland, CG5

Bromus erectus–Brachypodium pinnatum grassland and CG7 *Festuca ovina–Hieraceum pilosella–Thymus praecox/pulegioides* grassland. However, ecologically, these three communities do not fit the Fleetwood North community. The Community does not fit with OV23 due to the lack of *Lolium perenne* in the community. **Fleetwood North is classed as MG1a due to the grass species present.**

2.3.2.11 Fleetwood South

TABLE 2.13 FLEETWOOD SOUTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Arrhenatherum elatius	6	7	7	5	7	**V**
***Rubus fruticosus* agg.**	4	5	5	4	5	**V**
***Taraxacum officinale* agg.**	1	1	1		1	**IV**
Convolvulus arvensis	1	1	1		1	**IV**
Senecio jacobaea	1	1	1	1		**IV**
Chamerion angustifolium		2	4	1	1	**IV**
Geum urbanum		2	2	1	4	**IV**
Epilobium parviflorum	1	1			1	**III**
Salix caprea (sap)	4	1		1		**III**
Epilobium montanum		1	1	1		**III**
Poa pratensis			2	4	1	**III**
Tragopogon pratensis	1		1			**II**
Epilobium palustre	1					**I**
Bromus hordeaceus	1					**I**
Acer pseudoplatanus (sap)		1				**I**
Buddleja davidii		3				**I**
Salix cinerea (sap)			4			**I**
Holcus lanatus			1			**I**
Vulpia bromoides				1		**I**
Agrostis stolonifera				1		**I**
Plantago lanceolata				1		**I**
Brachythecium rutabulum					1	**I**
Ceratodon purpureus					1	**I**
TOTAL SPECIES: 23	**10**	**12**	**12**	**11**	**10**	
Top four MAVIS results:	**FIT**					
SD18b	**31.1**					
SD7a	**29.1**					
SD18	**28.9**					
SD7c	**28.8**					

The Fleetwood South site was situated on flat ground, surrounded by housing and gardens. The vegetation comprised predominantly *Arrhenatherum elatius* with Bramble encroaching over the rails. The vegetation cover was, on average, 65%. A total of 23 species were recorded including seven constant species. These included *Convolvulus arvensis* and *Chamerion angustifolium*.

The CA shows Fleetwood South as very close to MG1 *Arrhenatherum elatius* grassland. The dominance of *Arrhenatherum elatius* and the general physiognomy at Fleetwood South matches that of MG1 although the absence of tall Umbellifers and the presence of ruderal species which are not found in MG1 does not match MG1.

However, the top MAVIS result for Fleetwood South was SD18b *Hippophae rhamnoides* dune scrub *Urtica dioica–Arrhenatherum elatius* sub-community. This NVC community matches none of the constants recorded at Fleetwood South so this community is rejected. SD7a *Ammophila arenaria-Festuca rubra* fixed dune community typical sub-community and *Ononis repens* sub-community (second and fourth MAVIS results) can be rejected also due to the lack of *Ammophila arenaria* and the fact that SD7 is ecologically very different habitat to the Fleetwood South community. A poor fit occurred with OV27 *Epilobium angustifolium* community which included constants *Chamerion angustifolium*, *Rubus fruticosus* agg. and *Senecio jacobaea.* **The Fleetwood South site is classed as having affinities with MG1a.**

2.3.2.12 Gobowen to Oswestry

TABLE 2.14 GOBOWEN TO OSWESTRY						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Arrhenatherum elatius	5	6	6	6	7	**V**
Poa annua	2	1	1	1	1	**V**
Ceratodon purpureus	4	2	4	4	2	**V**
Chamerion angustifolium	2	1	1	2	1	**V**
***Rubus fruticosus* agg.**	4	1	1	1	1	**V**
Senecio jacobaea	1	1	1	1	1	**V**
Plantago major	2	1		1	1	**IV**
Lolium perenne	1	2	2	1		**IV**
Vicia sativa	1		1	1	1	**IV**
Mercurialis perennis	1	1	1	1		**IV**
Brachythecium rutabulum	1	1		1	4	**IV**
Urtica dioica	1	1		1	1	**IV**
Epilobium montanum	1		1	1		**III**
Sonchus asper		1	1	1		**III**
Heracleum sphondylium			1	1	1	**III**
Veronica arvensis			1	1	1	**III**
Cirsium arvense	1	1				**II**
Geum urbanum	1	1				**II**
Primula vulgaris		1	1			**II**
Taraxacum officinale agg.			1	1		**II**
Stellaria media			1	1		**II**
Digitalis purpurea	1					**I**
Anagallis arvensis		1				**I**
Agrostis stolonifera		1				**I**
Crataegus monogyna (sap)			1			**I**
Glechoma hederacea				1		**I**
Holcus lanatus				1		**I**
Rumex acetosa				1		**I**
Agrostis capillaris				1		**I**
Asplenium ruta-muraria				1		**I**
Sagina procumbens					1	**I**
Convolvulus arvensis					1	**I**
*Galium album** (*Galium mollugo*)					1	**I**
TOTAL SPECIES: 33	**16**	**17**	**17**	**23**	**15**	
Top four MAVIS results:	**FIT**					
OV21	**41.4**					
OV10	**40.7**					
OV24	**39.8**					
W24	**39.5**					

The Gobowen to Oswestry site was situated on flat ground, surrounded by farmland. The site was slightly shaded in places by young trees and scrub. The tall grass *Arrhenatherum elatius* dominated the track and Bramble was encroaching across the rails. Vegetation cover was, on average, 60%. A total of 33 species were recorded including twelve constants. These included *Poa annua*, *Mercurialis perennis* and *Chamerion angustifolium.* All constants had very low coverage except *Arrhenatherum elatius.*

The CA shows the Gobowen to Oswestry plot as equidistant between MG1 *Arrhenatherum elatius* grassland and W24 *Rubus fruticosus-Holcus lanatus* underscrub albeit some distance from either. The top MAVIS result for Gobowen to Oswestry was OV21 *Poa annua–Plantago major* community. The Gobowen to Oswestry line supported *Poa annua* and *Plantago major* as constant species albeit with very low cover values, but OV21 is a habitat of trampled areas with low-growing vegetation which does not support *Arrhenatherum elatius*, the main constituent of this site. OV10 *Poa annua-Senecio vulgaris* community is typically of open, moist and trampled habitats that have a soil substrate plus *Senecio vulgaris* did not occur at this site, therefore OV10 is rejected. OV24 *Urtica dioica-Galium aparine* community was the third MAVIS result. Despite *Urtica dioica* being a constant species at Gobowen to Oswestry, OV24 is dominated by tall stands of the species. At this site, it was recorded as single specimens growing in the ballast. *Rubus fruticosus* agg. and *Arrhenatherum elatius* are recorded as constants and therefore W24b (*Arrhenatherum elatius–Heracleum sphondylium*) sub-community appeared to have some similarities with the community. The community does have affinities with MG1 and to W24 due to the presence of *Arrhenatherum elatius* and *Rubus fruticosus* agg. **Given the species assemblage present, and the dominance of *Arrhenatherum elatius*, this**

community has affinities to MG1 but with a ruderal element. To a lesser extent, the community also has elements of W24 with the presence of *Rubus fruticosus* agg.

2.3.2.13 Golborne Ash

TABLE 2.15 GOLBORNE ASH				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Arrhenatherum elatius	5	4	5	**V**
***Fraxinus excelsior* (sap)**	5	4	2	**V**
Festuca rubra	2	4	2	**V**
Bryoerythrophyllum recurvirostrum	1	1	2	**V**
***Rubus fruticosus* agg.**	4	5	5	**V**
Rhytidiadelphus squarrosus	5	4	2	**V**
Brachythecium rutabulum	2	4		**IV**
Epilobium montanum		1	1	**IV**
Crataegus monogyna		1		**II**
TOTAL SPECIES: 9	**7**	**9**	**7**	
Top four MAVIS results:	**FIT**			
SD9a	**29.5**			
SD5c	**23.9**			
MG1a	**23.9**			
SD6e	**23.3**			

The Golborne Ash site was situated on flat ground, surrounded by farmland. The track was surrounded by Ash trees and supported many Ash saplings growing on the ballast. The community was exceptionally species-poor with a low cover of bryophytes and grass species. The granite ballast looked as though it had been relatively recently laid. The plant abundance was low with an average of 45% cover. A low total of nine species were recorded, eight of them being constant species, including *Brachythecium rutabulum*, *Fraxinus excelsior* and *Rhytidiadelphus squarrosus.*

The top MAVIS result for Golborne Ash was SD9a *Ammophila arenaria*–*Arrhenatherum elatius* dune grassland typical sub-community. However, ecologically, this community does not fit with the railway community and *Ammophila arenaria* is absent. The second MAVIS result was SD5c *Leymus arenarius* mobile dune community *Festuca rubra* sub-community which can be rejected on ecological and floristic grounds. As can the fourth MAVIS result, SD6e *Ammophila arenaria* mobile dune community *Festuca rubra* sub-community on similar grounds. The Golborne Ash community did have affinities with MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community but due to the Ash saplings, the presence of Hawthorn and the Bramble, this community is rejected in favour of W24b *Rubus fruticosus–Holcus lanatus* underscrub *Arrhenatherum elatius–Heracleum sphondylium* sub-community. CA also positions this community close to W24. **This community is categorised as W24b.**

2.3.2.14 Golborne North

TABLE 2.16 GOLBORNE NORTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
***Rubus fruticosus* agg.**	5	5	5	5	5	**V**
Festuca rubra	5	4	4	4	7	**V**
Brachythecium rutabulum	4	4	4	2	4	**V**
Crataegus monogyna	1	1	1	1	1	**V**
***Scorzoneroides autumnalis** (Leontodon)*	1	1	1	1	2	**V**
Epilobium parviflorum	1	1	1	2	2	**V**
Calliergonella cuspidata	1	2	2	1	2	**V**
***Taraxacum officinale* agg.**	1	1	1	1	1	**V**
Kindbergia praelonga	1	4	4	4	4	**V**
Holcus lanatus	4	5	2		1	**IV**
Dactylis glomerata	4	2	1		1	**IV**
Plantago lanceolata	1	1	2		1	**IV**
Trifolium dubium	2	1	1		2	**IV**
Agrostis capillaris	1		1	1	1	**IV**
Epilobium montanum	1	1		1	1	**IV**
Arrhenatherum elatius		1	2	4	2	**IV**
Bryoerythrophyllum recurvirostrum		1	1	1	1	**IV**
Cerastium fontanum	1	1			1	**III**
Senecio jacobaea	1		1		1	**III**
Trifolium pratense	1		1		1	**III**
Tussilago farfara	1		1		4	**III**
Linum catharticum	1	1	1			**III**
Ranunculus acris	1	1		1		**III**
Sonchus oleraceus			1	1	1	**III**
Plantago major	1		1			**II**
Bromus hordeaceus	1	1				**II**
Rumex acetosa			1		1	**II**
Quercus robur (sap)				1	1	**II**
Agrostis stolonifera	4					**I**
Geranium dissectum	1					**I**
Lolium perenne			1			**I**
Stachys sylvatica			1			**I**
Ceratodon purpureus				1		**I**
Salix caprea (sap)					1	**I**
Anthriscus sylvestris					1	**I**
Heracleum sphondylium					1	**I**
Hypochaeris radicata					1	**I**
Centaurium erythraea					1	**I**
TOTAL SPECIES: 38	**25**	**20**	**25**	**17**	**29**	
Top four MAVIS results:	**FIT**					
MG7e	**50.3**					
OV23d	**46.4**					
MG6	**46.1**					
MG6b	**44.4**					

The Golborne North line was situated on relatively flat ground, surrounded by farmland. The ballast was open towards the centre of the track with taller vegetation growing close to the rails and Bramble encroaching across the track. The vegetation cover was an average of 60%. A total of 38 species were recorded including seventeen constants. Constants included *Scorzoneroides autumnalis*, *Holcus lanatus* and *Trifolium dubium* along with four species of bryophyte.

The CA shows the Golborne North plot close to W24 *Rubus fruticosus-Holcus lanatus* underscrub and *Rubus fruticosus* agg. was the most abundant species on the site. The top MAVIS result for Golborne North was MG7e *Lolium perenne* leys *Lolio–Plantaginetum* sub-community. Considering that *Lolium perenne* was not a constant species at Golborne North, MG7e seems erroneous. MG6 *Lolium perenne-Cynosurus cristatus* grassland was the third and fourth MAVIS result which can also be rejected due to the lack of *Cynosurus cristatus*. A closer match to the existing NVC communities was OV23d *Lolium perenne–Dactylis glomerata* community *Arrhenatherum elatius–Medicago lupulina* sub-community which matched five constant species; *Dactylis glomerata*, *Plantago lanceolata*, *Taraxacum officinale* agg., *Arrhenatherum elatius* and *Holcus lanatus.* OV23d was the second best fit in MAVIS. However, this can be rejected because OV23 occurs on established soils. In addition, the single specimen of *Lolium perenne* recorded at Golborne North allows this community to be discounted. This community does have affinities with MG1 *Arrhenatherum elatius* grassland but the grass species did not record high cover values compared to *Rubus fruticosus* agg. so this pushes the community away from MG1. **Given the abundance of *Rubus fruticosus* agg. in this community, and the presence of tree species as saplings, Golborne North is classed as W24.**

2.3.2.15 Golborne Sidings

TABLE 2.17 GOLBORNE SIDINGS							
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**6**	**F**
Festuca rubra	1	4	4	2	6	4	**V**
Anthriscus sylvestris	2	2	1		1	1	**V**
Dactylis glomerata	1	3	4	4	4	1	**V**
***Taraxacum officinale* agg.**	1	1	1		1	1	**V**
Arrhenatherum elatius	1	1	6	6	6	4	**V**
Equisetum arvense	1			4	3	1	**IV**
Holcus lanatus		1	1	1	5		**IV**
Senecio viscosus	3	3				3	**III**
Plantago lanceolata	1	1		1			**III**
Agrostis capillaris	2				1	1	**III**
Rubus fruticosus agg.	1			1		1	**III**
Rumex acetosa		1	1		2		**III**
Vicia sativa		1		1	1		**III**
Sonchus asper		1				1	**II**
Barbarea vulgaris		1		2			**II**
Heracleum sphondylium		1	1				**II**
Agrostis stolonifera			1	1			**II**
Vicia cracca				1	1		**II**
Senecio vulgaris		1					**I**
Senecio jacobaea		1					**I**
Galium aparine				1			**I**
Ranunculus repens				1			**I**
Fragaria vesca					1		**I**
Urtica dioica					1		**I**
Rumex crispus					1		**I**
Epilobium hirsutum					1		**I**
Linaria vulgaris						1	**I**
Crataegus monogyna						1	**I**
TOTAL SPECIES: 28	**10**	**15**	**9**	**13**	**15**	**12**	
Top four MAVIS results:	**FIT**						
MG1a	**55.5**						
MG9b	**51.2**						
MG1b	**51.0**						
MG1	**48.6**						

The Golborne Sidings site is situated on a slight embankment surrounded by arable land. The vegetation cover is low on the ballast with taller species such as grasses and Umbellifers nearer to the rails. The community included many ruderal species such as *Linaria vulgaris* and *Senecio vulgaris.* A total of 28 species were recorded from here which included seven constant species. These included *Festuca rubra*, *Equisetum arvense* and *Dactylis glomerata.*

The CA shows Golborne Sidings as closest to MG1 *Arrhenatherum elatius* grassland. The top MAVIS result for Golborne Sidings was to MG1a (*Festuca rubra* sub-community). Given the dominance of grasses within the community, MG1a is also the best fit when compared to the published tables. MG9b *Holcus lanatus–Deschampsia cespitosa* grassland *Arrhenatherum elatius* sub-community was the second match in MAVIS, however *Deschampsia cespitosa* did not occur within this community and MG9 is a community of damp soils. MG1 occurred as three out of the four MAVIS results and the community did support four constant grass species and *Anthriscus sylvestris* as a constant. **It has been decided to place this community within MG1a.**

2.3.2.16 Golborne South

TABLE 2.18 GOLBORNE SOUTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Arrhenatherum elatius	8	7	6	7	6	**V**
***Rubus fruticosus* agg.**	4	4	5	4	5	**V**
Bryoerythrophyllum recurvirostrum	4	4	4	1	1	**V**
Vicia sepium	2	4	1	1		**IV**
Festuca rubra	1	4	1	1		**IV**
Elytrigia repens		4	4	4	4	**IV**
Brachythecium rutabulum	4		4	4		**III**
Calliergonella cuspidata	4	2	2			**III**
Kindbergia praelongum	4	5	4			**III**
Equisetum arvense	1	6	4			**III**
Kindbergia praelonga	4	5	4			**III**
Ranunculus repens	1			1		**II**
Taraxacum officinale agg.	1		1			**II**
Epilobium montanum	1		1			**II**
Senecio jacobaea	1	1				**II**
Linaria vulgaris	1					**I**
Potentilla erecta	1					**I**
Sonchus oleraceus	1					**I**
Anthriscus sylvestris	1					**I**
Chamerion angustifolium	1					**I**
Epilobium parviflorum	1					**I**
Ceratodon purpureus	4					**I**
Salix caprea (sap)	1					**I**
Rumex crispus	1					**I**
Lolium perenne	1					**I**
Agrostis capillaris		2				**I**
Holcus lanatus			1			**I**
Centaurea nigra			1			**I**
Fraxinus excelsior (sap)			1			**I**
Galium aparine				1		**I**
Potentilla reptans				1		**I**
TOTAL SPECIES: 30	**23**	**11**	**15**	**10**	**4**	
Top four MAVIS results:	**FIT**					
MG1a	**47.0**					
MG1b	**42.6**					
MG1	**41.0**					
MG1c	**40.8**					

The Golborne South site was situated in a shallow cutting surrounded by farmland. The slopes of the cutting were dominated by scrub. The community was dominated by *Arrhenatherum elatius* with Bramble encroaching across the track. Bryophytes were abundant in addition to ruderal species. The vegetation cover averaged 90% over the granite ballast. A total of 30 species were recorded with six constants. These included *Vicia sepium*, *Elytrigia repens* and *Bryoerythrophyllum recurvirostrum.*

The CA shows the Golborne South plot very close to W24 *Rubus fruticosus–Holcus lanatus* underscrub. By comparison MG1 was suggested in all four MAVIS results. However, the presence of bryophytes and tree saplings within the community along with ruderal species, is more suggestive of W24b (*Arrhenatherum elatius–Heracleum sphondylium* sub-community) as is the presence of *Rubus fruticosus* agg. and *Arrhenatherum elatius* as constants. **The Golborne South community is classed as W24b.**

2.3.2.17 Histon to St. Ives East

TABLE 2.19 HISTON TO ST. IVES EAST				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Senecio viscosus	4	2	2	**V**
Scorzoneroides autumnalis*	2	2	2	**V**
Lamium album	4	2	2	**V**
Arenaria serpyllifolia* ssp. *leptoclados	2	2	2	**V**
***Helminthotheca echioides** (Picris echioides*)**	1	1	1	**V**
***Rubus fruticosus* agg.**	5	5		**IV**
Achillea millefolium	4		4	**IV**
Stellaria media	1	1		**IV**
Urtica dioica	1	1		**IV**
Knautia arvensis	4		4	**IV**
Lamium purpureum	4	2		**IV**
Dipsacus fullonum	2	4		**IV**
Epilobium montanum	1		1	**IV**
***Crataegus monogyna* (sap)**	1	1		**IV**
Geum urbanum	4	4		**IV**
Glechoma hederacea	2		2	**IV**
Cerastium fontanum	1	1		**IV**
Dactylis glomerata		4	2	**IV**
Cirsium arvense		1	1	**IV**
Chamerion angustifolium		2	4	**IV**
Rumex acetosa		1	1	**IV**
Chenopodium polyspermum	2			**II**
Senecio jacobaea	1			**II**
Veronica arvensis	1			**II**
Myosotis arvensis	2			**II**
Viola arvensis	2			**II**
Potentilla reptans	4			**II**
Taraxacum officinale agg.	1			**II**
Lactuca serriola		4		**II**
Prunella vulgaris		1		**II**
Geranium molle		2		**II**
Rosa pimpinellifolia		2		**II**
Hieraceum sp.		1		**II**
Poa annua		1		**II**
Veronica chamaedrys		1		**II**
Convolvulus arvensis		2		**II**
Solanum dulcamara		4		**II**
Berberis sp.		4		**II**
Fraxinus excelsior (sap)		1		**II**
Stachys sylvatica		1		**II**
Centaurea nigra		4		**II**
Hypericum perforatum			2	**II**
Tanacetum vulgare			4	**II**
Holcus lanatus			4	**II**
Conyza canadensis			4	**II**
Artemisia absinthium			4	**II**
Sedum acre			2	**II**

SPECIES/RELEVE	1	2	3	F
Pastinaca sativa			4	II
TOTAL SPECIES: 48	**24**	**30**	**20**	
Top four MAVIS results:	**FIT**			
MG1	**31.0**			
MG1d	**30.3**			
MG1a	**27.7**			
W24a	**27.0**			

The Histon to St. Ives East site was situated on a slight embankment, surrounded by buildings, gardens and disused land. The community was species-rich with low-growing ruderal species dominating and Bramble encroaching across the rails. The vegetation coverage over the ballast was on average 75%, with most plants occurring near to the rails with open ballast in the centre. A total of 48 species were recorded here, including 21 constant species. These included *Glechoma hederacea*, *Knautia arvensis*, *Dipsacus fullonum* and *Scorzoneroides autumnalis.*

The CA shows the Histon to St. Ives East plot as distant from any of the four NVC community plots. The top three MAVIS results for Histon to St. Ives East were MG1 *Arrhenatherum elatius* grasslands. However the combination of ruderal constants and absence of grass constants (indeed *Arrhenatherum elatius* is absent here*)* means that MG1 is an inappropriate allocation. A sub-community of the closest community on the CA plot (OV23d *Lolium perenne–Dactylis glomerata* community *Arrhenatherum elatius–Medicago lupulina* sub-community is a slightly better match due to the presence of annual species and the constants *Achillea millefolium* and *Dactylis glomerata.* However, OV23 is typical of previously managed sites with well established soil. In addition, *Lolium perenne* is absent. Hence OV23 is also an inappropriate designation. W24a *Rubus fruticosus-Holcus lanatus* underscrub *Cirsium arvense-Cirsium vulgare* sub-community was the fourth MAVIS result. However, the community does not have the physiognomy of scrub, and given the number of ruderal species, W24 can be rejected. **Due to the species assemblage at this site, and the location on the CA, this community does not match any existing NVC community**.

2.3.2.18 Histon to St. Ives West

TABLE 2.20 HISTON TO ST. IVES WEST						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
***Rubus fruticosus* agg.**	5	2	4	4	4	**V**
Medicago lupulina	5	8	4	8	5	**V**
Achillea millefolium	4		4	4	4	**IV**
Lolium perenne	4	4	4		4	**IV**
Centaurea nigra	2		4	2	4	**IV**
Leucanthemum vulgare	4		2	4	2	**IV**
Pilosella officinarum		4	4	4	4	**IV**
***Crataegus monogyna* (sap)**		2	4	2	2	**IV**
Cerastium glomeratum		1	1	1	2	**IV**
Scorzoneroides autumnalis*		3	1	2	4	**IV**
Geranium molle	4	4	1			**III**
Hypericum perforatum	4	4	1			**III**
Galium verum	2	5		2		**III**
Prunella vulgaris	1	1	1			**III**
Sonchus asper		4	2	2		**III**
Rumex acetosa		2		1	4	**III**
Senecio jacobaea		4	2	4		**III**
Veronica chamaedrys		1		2	4	**III**
Pastinaca sativa		4		4	4	**III**
Knautia arvensis		4	4	2		**III**
Myosotis arvensis		2	2	1		**III**
Plantago lanceolata			4	4	4	**III**
Chamerion angustifolium			2	1	2	**III**
Brachypodium sylvaticum	4		5			**II**
Verbascum thapsus	4		4			**II**
Festuca rubra	4			1		**II**
Dactylis glomerata		1	4			**II**
Geranium dissectum		2	1			**II**
Bellis perennis		1	1			**II**
Holcus lanatus		4			4	**II**
Taraxacum officinale agg.		2	2			**II**
Viola canina agg.		1	4			**II**
Rosa pimpinellifolia		3		1		**II**
Urtica dioica		1	2			**II**
Epilobium sp.		2	1			**II**
Arenaria serpyllifolia ssp. *leptoclados*			4		2	**II**
Arrhenatherum elatius				4	6	**II**
Daucus carota				1	4	**II**
Senecio viscosus	4					**I**
Agrostemma githago	2					**I**
Conyza canadensis	4					**I**
Solanum dulcamara	2					**I**
Betula sp. (seedling)	1					**I**
Stachys sylvatica	2					**I**
Stellaria media	2					**I**
Arabidopsis thaliana	1					**I**
Lamium album	2					**I**
Ceratodon purpureus		2				**I**

SPECIES/RELEVE	1	2	3	4	5	F
Geum urbanum		4				I
Poa annua		2				I
Cirsium arvense		1				I
Agrimonia eupatoria		5				I
Arctium minus		2				I
Trifolium micranthum		1				I
*Poterium sanguisorba** (*Sanguisorba minor*)			4			I
Trifolium repens			3			I
Plantago major			2			I
*Helminthotheca echioides** (*Picris echioides*)			4			I
Cirsium vulgare			2			I
Linaria vulgaris			1			I
Dipsacus fullonum			4			I
Odontites vernus				1		I
Vicia tetrasperma					4	I
Chaenorhinum minus					1	I
Equisetum arvense					4	I
TOTAL SPECIES: 65	**22**	**34**	**36**	**24**	**22**	
Top four MAVIS results:	**FIT**					
MG1	**41.4**					
OV23	**39.2**					
MG1d	**39.1**					
MG1a	**37.5**					

The Histon to St. Ives West line was situated within a cutting. An old platform occurred along the edge of one of the relevés. The slopes on either side of the track were species-rich with ruderal and calcareous species including abundant *Pastinaca sativa.* The ballast community was also species-rich with many low-growing ruderal species and taller species nearer to the rails. The average vegetation cover was 80% over the ballast. A total of 65 species were recorded which is species-rich in comparison to other sites. Ten species were classed as constants including *Medicago lupulina*, *Leucanthemum vulgare*, *Scorzoneroides autumnalis* and *Centaurea nigra.*

The CA shows the Histon to St. Ives West plot as distant from any of the four NVC community plots. Three of the top four MAVIS results identify it as an

MG1 *Arrhenatherum elatius* grassland. However, *Arrhenatherum elatius* and *Holcus lanatus* were infrequently recorded at this site and the community cannot be described as a grassland. Comparing the NVC tables, OV23d *Lolium perenne–Dactylis glomerata* community *Arrhenatherum elatius–Medicago lupulina* sub-community appears to be a slightly better fit. OV23d includes *Lolium perenne*, *Medicago lupulina* and *Achillea millefolium* as constant species which Histon to St. Ives West matches. OV23 was the second result from MAVIS for this community but OV23 is rejected due to the lack of established soil which typifies OV23 and the combination of ruderal and calcareous species present. **Due to the species-rich assemblage, with some calcareous species and many ruderal species, and given the location of the plot on CA, this community cannot be placed within an existing NVC classification.**

2.3.2.19 Leek to Cauldon Quarry

TABLE 2.21 LEEK TO CAULDON QUARRY											
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**F**
Festuca rubra	6	8	4	3	6	7	5	7	5	6	**V**
Brachythecium rutabulum	2	2	3	2	4	5	5	5	4	5	**V**
Deschampsia cespitosa	6	1	1	1	1	4	4	4	3		**V**
Taraxacum officinale	2	3	1		2	2	4	4	2	1	**V**
Vicia sepium	1	4	1	3	1	3		4		1	**IV**
Heracleum sphondylium	2		1	1	2		1	2	4	4	**IV**
Dactylis glomerata	2	4			2	4	4	4	4	2	**IV**
Rubus fruticosus agg.		1	4	1			2	4	2		**III**
Arrhenatherum elatius	5	2	7	7	2	1					**III**
Holcus lanatus	2		1	1		4		4	4		**III**
Chamerion angustifolium	1		1			4	1	2			**III**
Crataegus monogyna (sap)	1	1	1		1		1				**III**
Poa pratensis	1	1				4		4	4	2	**III**
Bryum capillaire	2	2	1	2	2						**III**
Senecio jacobaea						4	4	2	4		**II**
Urtica dioica	1			1	1						**II**
Hieraceum sp.	1	1				1					**II**
Angelica sylvestris	1	1			2		4				**II**
Rhytidiadelphus squarrosus		1		1	1						**II**
Valeriana officinalis						4		4	4		**II**
Alopecurus pratensis							4	1	4		**II**
Betula pubescens (sap)							4	4	4		**II**
Dryopteris felix-mas	1										**I**
Potentilla sterilis	1								1		**I**
Geranium robertianum			2								**I**
Sonchus asper						4	1				**I**
Betula sp. (sap)	1	1									**I**
Nardus stricta	2										**I**
Fragaria vesca	1										**I**
Rosa arvensis	1										**I**
Sorbus aucuparia (sap)	1										**I**
Centaurea nigra	1	2									**I**
Leontodon autumnalis		3									**I**
Salix cinerea (sap)		1									**I**
Trisetum flavescens		2									**I**
Cirsium vulgare		1									**I**
Ranunculus repens					1						**I**
Hieraceum sp. (diff)		1									**I**
Epilobium montanum				1							**I**
Vicia cracca		1									**I**
Potentilla erecta				1							**I**
Galium aparine			1								**I**
Epilobium hirsutum				1							**I**
Lathyrus pratensis			2					3			**I**
Barbula recurvirostra			1								**I**
Calliergon cuspidatum			3								**I**
Equisetum arvense			3								**I**
Lapsana communis						2					**I**

SPECIES/RELEVE	1	2	3	4	5	6	7	8	9	10	F
Primula vulgaris						1					I
Ranunculus acris						4					I
Ilex aquifolium							1				I
Corylus avellana									1		I
*Schedonorus pratensis** (*Festuca pratensis*)									4		I
Festuca ovina									2		I
Epilobium sp.									2		I
Geum urbanum									2		I
TOTAL SPECIES: 56	**24**	**22**	**18**	**14**	**14**	**17**	**15**	**16**	**19**	**7**	
Top four MAVIS results:	**FIT**										
MG1a	**46.4**										
W24b	**46.4**										
MG1	**45.1**										
W24	**44.4**										

The Leek to Cauldon Quarry line was situated on an exposed embankment. The community comprised tall tufted grasses growing close to the rails with low-growing species, including some acidic grassland species, occurring sporadically across the ballast. The surrounding land was permanent pasture, grazed by livestock which had no access to the railway line. A total of 56 species were recorded from this site with a total of seven constant species. These included *Vicia sepium*, *Heracleum sphondylium*, *Festuca rubra* and the moss *Brachythecium rutabulum*. The latter two species achieved high Domin scores, the rest of the constant species had low cover values. The average ballast cover was 70%.

The CA shows the Leek to Cauldon Quarry plot as equidistant between MG1 *Arrhenatherum elatius* grassland and W24 *Rubus fruticosus–Holcus lanatus* underscrub. The top MAVIS result for the Leek to Cauldon line was to both MG1a (*Festuca rubra* sub-community) and W24b (*Arrhenatherum elatius-Heracleum sphondylium* sub-community). The Leek to Cauldon Quarry line did not support *Arrhenatherum elatius* as a constant species, neither were *Rubus fruticosus* agg. nor *Holcus lanatus* recorded as constants. **This community has affinities with both MG1 (given the presence of tall grass species and Umbellifers) and W24 (given the Bramble and the presence of tree species as saplings) but the community cannot be placed within any existing NVC community.**

2.3.2.20 Leek to Cauldon Quarry Wooded

TABLE 2.22 LEEK TO CAULDON QUARRY WOODED				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Vicia sepium	2	2	4	**V**
***Rubus fruticosus* agg.**	4	3	4	**V**
Brachythecium rutabulum	6		5	**IV**
Dactylis glomerata	7		4	**IV**
Chamerion angustifolium		4	3	**IV**
Senecio jacobaea	2		3	**IV**
Dryopteris felix-mas		4	4	**IV**
Geranium robertianum		1	1	**IV**
Sonchus asper	2		3	**IV**
Betula pubescens		4	1	**IV**
Agrostis capillaris		4	4	**IV**
Festuca rubra			4	**I**
Heracleum sphondylium			1	**I**
Taraxacum officinale agg.			2	**I**
Arrhenatherum elatius	2			**I**
Holcus lanatus	5			**I**
Crataegus monogyna			1	**I**
Angelica sylvestris	4			**I**
Potentilla sterilis			1	**I**
Sorbus aucuparia		2		**I**
Scorzoneroides autumnalis			4	**I**
Ranunculus repens			4	**I**
Galium aparine	1			**I**
Epilobium sp.		2		**I**
Geum urbanum		4		**I**
Epilobium parviflorum		2		**I**
Prunella vulgaris		1		**I**
Scrophularia nodosa		2		**I**
Salix sp.			1	**I**
Poa annua			4	**I**
Medicago lupulina			1	**I**
TOTAL SPECIES: 31	**10**	**13**	**21**	
Top four MAVIS results:	**FIT**			
W24	**36.8**			
W24b	**35.6**			
W24a	**35.1**			
MG1a	**33.0**			

The Leek to Cauldon Quarry Wooded site was situated on a low embankment with dense woodland either side of the track. In parts, the vegetation covered most of the ballast whereas in other places, the ballast was relatively open. The community comprised isolated grass species with Umbellifers and tree saplings and some ruderal species. A total of 31 species were recorded here with eleven constant species, most of which were recorded with low Domin scores. Constants included *Vicia sepium*, *Dryopteris felix-mas*, *Sonchus asper* and *Chamerion angustifolium.*

The CA shows the Leek to Cauldon Quarry Wooded plot as closest to W24 *Rubus fruticosus–Holcus lanatus* underscrub albeit some distance from the W24 plot. The top MAVIS result for this small section of shaded line was to W24 *Rubus fruticosus–Holcus lanatus* underscrub with W24b (*Arrhenatherum elatius–Heracleum sphondylium* sub-community) the second best match. Comparing the published NVC tables, W24b fits best due to the rank grasses (e.g. *Dactylis glomerata*) and Umbellifers (e.g. *Heracleum sphondylium*) which were recorded frequently. MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community, the fourth MAVIS result, can be rejected due to the very low cover of *Arrhenatherum elatius.* **Given the Bramble and tree saplings present on the site and the location of the CA plot, this community is classed as having affinities to W24 but is difficult to place clearly within an existing NVC community.**

2.3.2.21 Leek to Stoke

TABLE 2.23 LEEK TO STOKE							
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**6**	**F**
***Epilobium* sp.**	4	4	4	2	3	4	**V**
***Taraxacum officinale* agg.**	4	4	4	2	4	4	**V**
Senecio jacobaea	4	4	4		1	4	**V**
Festuca rubra	6	6	6	5	7	6	**V**
Chamerion angustifolium	2	4	4	4	2	4	**V**
Sonchus asper	2	4	2	2	2		**V**
Arabidopsis thaliana	4	2	2	4	1	1	**V**
Angelica sylvestris	4	4	1	2		2	**V**
Brachythecium rutabulum	4	5	4	4		4	**V**
Rubus idaeus		4	2	2	1	1	**V**
Holcus lanatus		5	4	4	4	4	**V**
Dactylis glomerata	1	4	4		4		**IV**
Rhytidiadelphus squarrosus	4			4	4	4	**IV**
***Hieraceum* sp.**		1	4		1	1	**IV**
Pilosella officinarum		1	4	4	4		**IV**
Hypochaeris radicata			4	4	2	4	**IV**
Rubus fruticosus agg.	1	2	1				**III**
Linaria vulgaris	4	2				1	**III**
Plantago lanceolata	4		1		1		**III**
Potentilla sterilis		4	2			3	**III**
Bellis perennis		4	4		1		**III**
Ranunculus acris		1	2	2			**III**
Solanum dulcamara		4		1		1	**III**
Barbula sp.		4		3	5		**III**
Vicia sepium				2	4	4	**III**
Poa annua	5	5					**II**
Trifolium repens	4				1		**II**
Cirsium vulgare	1	1					**II**
Lolium perenne	4			4			**II**
Cerastium fontanum	1	2					**II**
Vicia sativa	4	4					**II**
Rosa arvensis	2			4			**II**
Valeriana officinalis	1		3				**II**
Veronica arvensis	1	4					**II**
Scrophularia nodosa		2			2		**II**
Lapsana communis		1		1			**II**
Heracleum sphondylium		1		1			**II**
Cirsium arvense		1	4				**II**
Bryum sp.			4			4	**II**
Hypnum cupressiforme			2			4	**II**
Lathyrus pratensis				4		4	**II**
Alopecurus pratensis				2		5	**II**
Crataegus monogyna (sap)					1	1	**II**
Leucanthemum vulgare	4						**I**
Hieraceum sp.	4						**I**
Vicia cracca	5						**I**
Plantago major	4						**I**
Urtica dioica	1						**I**

SPECIES/RELEVE	1	2	3	4	5	6	F
Salix sp. (sap)	1						I
Vicia hirsuta	4						I
Racomitrium sp.	2						I
Amblystegium serpens var. serpens	2						I
Arenaria serpyllifolia		1					I
Veronica chamaedrys		1					I
Filipendula ulmaria		2					I
Kindbergia praelongum		1					I
Lophocolea sp.		4					I
Calliergon cuspidatum		4					I
Viola canina agg.			2				I
Campylopus introflexus			2				I
Polytrichum commune			3				I
Digitalis purpurea				4			I
Luzula multiflorum				4			I
Deschampsia cespitosa				4			I
Cirsium palustre				4			I
Epilobium parviflorum				4			I
Trifolium campestre					1		I
Anthriscus sylvestris					4		I
Cardamine hirsuta					2		I
Agrostis capillaris					4		I
Phleum pratense					4		I
Dipsacus fullonum						4	I
Arrhenatherum elatius						4	I
Galium aparine						1	I
TOTAL SPECIES: 74	**32**	**36**	**27**	**28**	**26**	**25**	
Top four MAVIS results:	**FIT**						
MG1a	**37.6**						
MG1	**37.4**						
MG6a	**36.9**						
MG5	**36.8**						

The Leek to Stoke line was situated on relatively flat ground with a slight decline on the south side leading down to the Caldon Canal. The vegetation covering was on average 75% on the ballast with taller vegetation occurring nearer to the rails and Raspberry encroaching across the rails. A total of 74 species were recorded with sixteen constant species. These are predominantly ruderal species and include *Arabidopsis thaliana*, *Sonchus asper*, *Angelica sylvestris* and *Pilosella officinarum.* These all exhibited low ground cover values. Twelve species of bryophyte were also recorded here.

The CA shows the Leek to Stoke plot as close to both MG1 *Arrhenatherum elatius* grassland and W24 *Rubus fruticosus-Holcus lanatus* underscrub. The top MAVIS result for the Leek to Stoke sample was MG1a (*Festuca rubra* sub-community). Only *Festuca rubra* matches the constants in the MG1 community (*Arrhenatherum elatius* is only present on one relevé). Likewise the low cover of *Rubus fruticosus* agg. eliminates W24 as the community at this site. MG6a *Lolium perenne-Cynosurus cristatus* grassland typical sub-community was the third MAVIS result but the Leek to Stoke community did not support *Cynosurus cristatus* and *Lolium perenne* was not recorded as constant. MG5 *Cynosurus cristatus-Centaurea nigra* grassland was the fourth MAVIS result. Neither of these title species were recorded at Leek to Stoke so this community can be rejected. **The combination of constant species in the Leek to Stoke community mean that it does not fit into any existing NVC community. The CA has to be disregarded in this instance.**

2.3.2.22 Newport to Ebbw Vale

TABLE 2.24 NEWPORT TO EBBW VALE				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Arrhenatherum elatius	8	8	5	**V**
***Fraxinus excelsior* (sap)**	4	2	2	**V**
Hedera helix	2	1	2	**V**
Geranium robertianum	1	1	3	**V**
Epilobium montanum	1		1	**IV**
Equisetum arvense	1	1		**IV**
***Epilobium* sp.**	1		1	**IV**
Senecio jacobaea	1		1	**IV**
***Rubus fruticosus* agg.**	2		2	**IV**
Bromus hordeaceus	4	4		**IV**
Crepis vesicaria	4		1	**IV**
Plantago lanceolata	2	2		**IV**
Epilobium hirsutum	2	2		**IV**
***Taraxacum officinale* agg.**	1	1		**IV**
Oenothera biennis	4	1		**IV**
Holcus lanatus	2	5		**IV**
Trifolium pratense	1	1		**IV**
Verbena officinalis	1	1		**IV**
Geum urbanum	4			**II**
Epilobium parviflorum	2			**II**
Salix sp. (sap)	3			**II**
Sonchus asper	4			**II**
Trifolium dubium	5			**II**
Lolium perenne	4			**II**
Cymbalaria muralis	1			**II**
Prunella vulgaris	1			**II**
Stachys sylvatica	1			**II**
Vicia hirsuta	1			**II**
Geranium dissectum	1			**II**
Veronica persica	1			**II**
Poa trivialis	4			**II**
Galium album	1			**II**
Festuca rubra	2			**II**
Heracleum sphondylium	2			**II**
Chaenorhinum minus	1			**II**
Trifolium dubium		2		**II**
Dactylis glomerata		5		**II**
Rumex conglomeratus		1		**II**
Polygonum aviculare		1		**II**
Cynosurus cristatus		2		**II**
Agrostis stolonifera		2		**II**
Hypericum tetrapterum		1		**II**
Plantago major		2		**II**
Acer pseudoplatanus (sap)			1	**II**
Campylopus introflexus			2	**II**
Brachythecium rutabulum			1	**II**
Corylus avellana (sap)			1	**II**
Quercus sp. (sap)			1	**II**

SPECIES/RELEVE	1	2	3	F
Buddleja davidii			1	II
Asplenium adiantum-nigrum			1	II
Chamerion angustifolium			2	II
Betula pendula (sap)			1	II
TOTAL SPECIES: 52	**35**	**21**	**18**	
Top four MAVIS results:	**FIT**			
OV23	**37.2**			
W24	**33.6**			
OV23c	**33.1**			
MG1a	**32.9**			

The Newport to Ebbw Vale site was situated in a shallow cutting. To the north lay ex-industrial land covered with ruderal vegetation. To the south lay an A road and housing. The community comprised tall *Arrhenatherum elatius* growing close to the rails with scattered tree saplings and many ruderal species. The vegetation cover was, on average, 75% on the ballast. A total of 52 species were recorded here with eighteen of these being constants. Constant species included *Verbena officinalis*, *Fraxinus excelsior* (sapling), *Senecio jacobaea* and *Oenothera biennis.*

The top MAVIS result for Newport to Ebbw Vale was OV23 *Lolium perenne–Dactylis glomerata* community. This can be rejected due to the very low cover of both these species at the site. The second best fit from MAVIS was W24 *Rubus fruticosus–Holcus lanatus* underscrub. The Newport to Ebbw Vale community included *Fraxinus excelsior* saplings and *Hedera helix* as well as W24 constants *Rubus fruticosus* agg., *Holcus lanatus*, *Taraxacum officinale* agg. and *Arrhenatherum elatius.* However, *Rubus fruticosus* agg. and *Holcus lanatus* were recorded with very low cover values. MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community was the fourth MAVIS result.

This can be explained by the constants *Arrhenatherum elatius* and *Holcus lanatus.* And the former species did have high cover values. However, the combination of ruderal species and tree saplings are not characteristic of MG1. The CA plot shows the Newport to Ebbw Vale plot as equidistant from W24 and MG1 albeit some distance from either. **This community is therefore classed as having affinities to MG1 and W24 but cannot be placed exactly into either.**

2.3.2.23 Oswestry North Embankment

TABLE 2.25 OSWESTRY NORTH EMBANKMENT						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Arrhenatherum elatius	4	6	5	5	7	**V**
Buddleja davidii	7	5	6	5	7	**V**
***Rubus fruticosus* agg.**	1	2	2	2	4	**V**
Epilobium montanum	1	1		1	1	**IV**
Geum urbanum	1	1	1	1		**IV**
Holcus lanatus	2	4		1		**III**
Lolium perenne	1	1			4	**III**
Trifolium dubium	2	1	1			**III**
Rhytidiadelphus squarrosus	2			1	1	**III**
Betula pendula (sap)	2		4		4	**III**
Salix caprea (sap)		4	7	5		**III**
Leontodon hispidus	2	1				**II**
Senecio jacobaea	1	1				**II**
Tragopogon pratensis	1	1				**II**
Convolvulus arvensis	1	1				**II**
Chamerion angustifolium	1	4				**II**
Calliergonella cuspidata	1			1		**II**
Sagina procumbens	1	1				**II**
Festuca rubra	1				1	**II**
Poa annua	1	1				**II**
Dipsacus fullonum	1	1				**II**
Crataegus monogyna (sap)		1		1		**II**
Vicia hirsuta	4					**I**
Hedera helix	1					**I**
Hypochaeris radicata	1					**I**
Vulpia bromoides	4					**I**
Hypericum sp.	1					**I**
Ceratodon purpureus	2					**I**
Agrostis capillaris	1					**I**
Geranium dissectum	1					**I**
Prunella vulgaris	1					**I**
Acer pseudoplatanus (sap)	1					**I**
Trifolium campestre	1					**I**
Epilobium parviflorum	1					**I**
Plantago lanceolata	1					**I**
Lapsana communis	1					**I**
Poa trivialis		1				**I**
Urtica dioica		1				**I**
Galium album		1				**I**
Geranium molle		1				**I**
Mercurialis perennis		1				**I**
Plantago major		1				**I**
Poa pratensis					1	**I**
Dactylis glomerata					1	**I**
Fragaria vesca					1	**I**

TOTAL SPECIES: 45	34	24	7	10	11	
Top four MAVIS results:	FIT					
OV23	40.4					
W24	39.3					
MG1a	38.0					
MG1	36.1					

The Oswestry North Embankment site was on a viaduct. On the edge of the track was tall scrub. Tall vegetation, mainly Buddleja and *Arrhenatherum elatius*, dominated the track with Bramble beneath and the vegetation cover averaged 60%. This was a relatively species-rich railway line. A total of 45 species were recorded including five constants. These included *Buddleja davidii* and *Geum urbanum* though no existing NVC community includes these species as constants.

The top MAVIS result for Oswestry North Embankment was OV23 *Lolium perenne–Dactylis glomerata* community. However, OV23 matches only *Arrhenatherum elatius* as a constant species and ecologically does not fit the community. MG1 *Arrhenatherum elatius* grassland came out as third and fourth MAVIS results. Despite *Arrhenatherum elatius* being constant in the community, MG1 can be rejected due to the lack of grassland physiognomy and the presence of ruderal and scrub species. The scrub species are characteristic of W24 and this is supported by the position on the CA plot, although the presence of Buddleja and ruderals as constants are untypical of the community. **This community is classed as W24 with Buddleja.**

2.3.2.24 Runcorn Docks

TABLE 2.26 RUNCORN DOCKS											
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**F**
Vulpia bromoides	6	7	6	7	6	5	5	4	4	2	**V**
Galium aparine	2	2	2	1	2	1	1	1	1		**V**
Senecio jacobaea	2	1	1	1	1	1	1	1		1	**V**
Arrhenatherum elatius	5	4	4	4	4	5	5	4	5	5	**V**
Sonchus asper	1	2	2	4	1	1	1	2	2	1	**V**
***Taraxacum officinale* agg.**	1	2	1	1	1	1	1		1	1	**V**
Anthriscus sylvestris		1	2	1	2	2	1	1	2	2	**V**
Holcus lanatus	2		4	2	2	1	2	2			**IV**
Veronica arvensis	1	1		1	1	1	1	1			**IV**
Cerastium fontanum	1	1	1	1		1	1	1			**IV**
Epilobium montanum	1	1	1	1	1	1	1				**IV**
Pimpinella saxifraga	2		2	1		1	2	1	2		**IV**
Helminthotheca echioides*	1		2	4	1	1	2			1	**IV**
Hypochaeris radicata	2	3	2		2				1	1	**III**
Heracleum sphondylium	2	1	1	1			1	1			**III**
Centaurium erythraea	1	1	1	1	1						**III**
Linum catharticum	1	1	1		1	1		1			**III**
Dactylis glomerata		2	1	2	2	2				1	**III**
Senecio viscosus		1		1	1	1			1		**III**
Hieraceum sp.		1	1		1	1	2			1	**III**
Rubus fruticosus agg.	1	1	2		1						**II**
Conyza canadensis	2	1	4			1					**II**
Epilobium parviflorum	1	1					1	1			**II**
Brachythecium rutabulum	2	1	4								**II**
Rumex crispus	4	2					1	2			**II**
Verbascum thapsus	1		2						1	1	**II**
Artemisia vulgaris	1		2	1							**II**
Solanum dulcamara	1	1			1						**II**
Cirsium arvense	1	2		2							**II**
Leontodon hispidus		1	1					1			**II**
Crepis vesicaria				1	1				1	1	**II**
Hypericum perforatum				1	2	1					**II**
Medicago lupulina						1	1	1	1		**II**
Equisetum arvense	1										**I**
Epilobium palustre	1			1							**I**
Cerastium glomeratum	1			1							**I**
Senecio jacobaea	1										**I**
Reseda luteola		1									**I**
Rumex acetosa		1									**I**
Deschampsia cespitosa		2									**I**
Cirsium vulgaris		1									**I**
Geranium robertianum		1									**I**
Anisantha sterilis			2								**I**
Tragopogon pratensis			3							1	**I**
Vicia cracca				1		1					**I**
Stachys sylvatica					1	2					**I**
Festuca rubra						1					**I**
Urtica dioica						1					**I**

SPECIES/RELEVE	1	2	3	4	5	6	7	8	9	10	F
Blackstonia perfoliata						1					I
Chamerion angustifolium							1	4			I
Scrophularia nodosa								2			I
Sambucus nigra (sap)								4			I
Plantago lanceolata								1			I
TOTAL SPECIES: 52	**28**	**30**	**26**	**24**	**22**	**25**	**19**	**20**	**12**	**13**	
Top four MAVIS results:	**FIT**										
MG1	**39.6**										
OV23	**39.2**										
W24	**38.7**										
MG1b	**37.9**										

The Runcorn Docks site was situated on a tall embankment between industrial buildings, to the west lay industrial buildings with a dual carriageway to the east. The vegetation comprised tufted grasses and low-growing herbaceous species over granite ballast. Vegetation cover averaged 50%. A total of 52 species were recorded, including thirteen constant species. These included *Veronica arvensis*, *Pimpinella saxifraga* and *Cerastium fontanum*.

The CA shows the Runcorn Docks plot as equidistant from OV23 *Lolium perenne–Dactylis glomerata* community and MG1 *Arrhenatherum elatius* grassland. The top MAVIS result for Runcorn Docks was MG1. This corresponds to several elements of the community; the constant *Arrhenatherum elatius* with the tall Umbellifers *Anthriscus sylvestris and Heracleum sphondylium plus Dactylis glomerata frequent. However* the community has a significant ruderal component which is not characteristic of MG1. OV23 can be rejected due to the lack of *Lolium perenne* and *Dactylis glomerata* from the constants. W24 *Rubus fruticosus–Holcus lanatus* underscrub (the third MAVIS result) can be rejected due to the low cover of

Rubus fruticosus agg. **The Runcorn Docks site is therefore classed as having affinities to MG1 but with a ruderal element.**

2.3.2.25 St. Helens Acid Works

TABLE 2.27 ST. HELENS ACID WORKS						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Arrhenatherum elatius	7	7	7	5	1	**V**
***Rubus fruticosus* agg.**	1	4	1	3	1	**V**
Festuca ovina	1	1	1	4	1	**V**
Holcus lanatus	1	1	1	1	1	**V**
Agrostis stolonifera	1	1	1	8	4	**V**
Stachys sylvatica	1	1	1	1		**IV**
***Salix cinerea* (sap)**	1	1		4	1	**IV**
Sonchus asper	1	1	1	1		**IV**
***Taraxacum officinale* agg.**		1	1	1	1	**IV**
Eupatorium cannabinum		1	3	7	1	**IV**
Senecio squalidus	1	1	1			**III**
Epilobium parviflorum		2	1		1	**III**
Calystegia sepium		1	2	1		**III**
Epilobium hirsutum		4		1	2	**III**
Crataegus monogyna	1	1				**II**
Acer pseudoplatanus (sap)	1		1			**II**
Vicia cracca		1			1	**II**
Chamerion angustifolium		1	1			**II**
Cerastium fontanum		1		1		**II**
Salix sp. (sap)		1	1			**II**
Rumex crispus		1			1	**II**
Epilobium sp.	1					**I**
Plantago lanceolata	1					**I**
Medicago lupulina	4					**I**
Sagina procumbens	1					**I**
Poa annua	1					**I**
Geranium robertianum	1					**I**
Linaria vulgaris	1					**I**
Prunus sp. (sap)		1				**I**
Tussilago farfara				1		**I**
Hypochaeris radicata				1		**I**
Lotus corniculatus				4		**I**
Solidago canadensis				1		**I**
Rosa canina				1		**I**
Hieraceum sp.				1		**I**
TOTAL SPECIES: 35	**18**	**21**	**15**	**19**	**12**	
Top four MAVIS results:	**FIT**					
OV23d	**32.5**					
OV23	**29.9**					
OV23c	**27.8**					
OV22a	**27.7**					

St. Helens Acid Works is situated in a flat area of land, sandwiched between factories and the derelict acid works site. Tall, ruderal vegetation exists on the land next to the track. The community was dominated by tall *Eupatorium cannabinum* and *Arrhenatherum elatius* growing near to the rails with ruderal species scattered on the ballast. Throughout the sample, the cover of the vegetation differed over the ballast. In places, the cover was sparse, in others the cover reached 95%. A total of 35 species were recorded here including ten constant species. These included *Eupatorium cannabinum*, *Agrostis stolonifera* and *Festuca ovina. Eupatorium cannabinum* is not identified as a constant in any NVC communities.

The CA shows the St. Helens Acid Works plot as closest to MG1 *Arrhenatherum elatius* grassland. The MAVIS results almost all identify OV23 *Lolium perenne–Dactylis glomerata* communities as the most similar. This result can be rejected due to the lack of both *Lolium perenne* and *Dactylis glomerata* at the site. This railway community has OV22a *Poa annua-Taraxacum officinale* community *Senecio vulgaris* sub-community was the fourth MAVIS result. This can be rejected due to the absence of *Poa annua*. Comparing MG1 and W24, the community supports more *Arrhenatherum elatius* than *Rubus fruticosus* agg. but does support tree and scrub species as saplings. **This community is classed as having affinities with MG1 and W24 but is an open community with constants that do not match any sub-communities of either MG1 or W24.**

2.3.2.26 St. Helens Canal North

TABLE 2.28 ST. HELENS CANAL NORTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Senecio jacobaea	2	1	1	4	1	**V**
***Taraxacum officinale* agg.**	1	1	1	1	1	**V**
Eupatorium cannabinum	5	5	5	4	4	**V**
Galium aparine	1	2	1	1	1	**V**
Epilobium parviflorum	1	1	2	1	1	**V**
Arrhenatherum elatius	2	2	1	1	4	**V**
Vulpia bromoides	4	5	4	4	2	**V**
Trifolium dubium	4	4	4	2	2	**V**
Holcus lanatus	1	2	4	4	2	**V**
Brachythecium rutabulum	1	4	1	4	1	**V**
Barbula convoluta	2	1	1	2	1	**V**
Festuca rubra	1	1	1	1	2	**V**
Agrostis stolonifera	4	4	2	2		**IV**
Linum catharticum	4	2	1	1		**IV**
Buddleja davidii	1		1	1	4	**IV**
Myosotis discolor	1	1	1	1		**IV**
***Betula pubescens* (sap)**	1	2	1	1		**IV**
Sonchus oleraceus	1		1	1	1	**IV**
Chamerion angustifolium	1		4	2	2	**IV**
Poa annua	1		1	1	1	**IV**
Agrostis capillaris		2	4	1	1	**IV**
Euphrasia officinalis		2	4	1	2	**IV**
Epilobium montanum		1	1	2	1	**IV**
Bryum argenteum		1	1	4	1	**IV**
Pastanica sativa	1	1	2			**III**
Epilobium palustre	1	1		1		**III**
Plantago major	1	1			1	**III**
Betula pendula (sap)	4	4	1			**III**
Salix caprea (sap)	4	2			2	**III**
Centaurium erythraea	1	1		1		**III**
Alnus glutinosa (sap)		2	4	2		**III**
Sagina procumbens		1	1		1	**III**
Centaurea nigra			1	1	2	**III**
Lolium perenne	1			1		**II**
Dactylis glomerata	1				2	**II**
Leontodon hispidus	1		1			**II**
Rubus fruticosus agg.	1	1				**II**
Daucus carota	1		1			**II**
Leucanthemum vulgare	1			1		**II**
Hypericum montanum	1				2	**II**
Hieraceum sp.		1		1		**II**
Cirsium arvense		1			1	**II**
Galium album			1	1		**II**
Salix cinerea (sap)			4	4		**II**
Vicia sativa	1					**I**
Erigeron acris	1					**I**
Festuca ovina	2					**I**
Pulicaria dysenterica	1					**I**

SPECIES/RELEVE	1	2	3	4	5	F
Tragopogon pratensis		1				I
Tussilago farfara		1				I
Hypochaeris radicata		1				I
Galium parisiense		1				I
Deschampsia cespitosa		1				I
Cerastium fontanum		1				I
Senecio vulgaris		1				I
Poa pratensis		1				I
Lycopus europaeus			1			I
Cirsium vulgare			1			I
Senecio squalidus			1			I
Trifolium pratense			1			I
Helminthotheca echioides				1		I
Lapsana communis				1		I
Plantago lanceolata				1		I
Ranunculus repens				1		I
Urtica dioica					1	I
Prunella vulgaris					1	I
Senecio viscosus					1	I
*Scorzoneroides autumnalis**					1	I
TOTAL SPECIES: 68	**37**	**39**	**37**	**37**	**31**	
Top four MAVIS results:	**FIT**					
OV23	**40.8**					
OV23d	**36.9**					
OV23c	**36.3**					
MG1	**35.5**					

The St. Helens Canal North site was situated on flat ground, in an urban setting. The line was species-rich, with many ruderal species, bryophytes, grasses and tree saplings. Tall *Eupatorium cannabinum* grew next to the rails. The vegetation cover was, on average, 75%. A total of 68 species were recorded including 24 constant species. These constants included *Buddleja davidii*, *Galium aparine*, *Linum catharticum* and *Vulpia bromoides*.

The CA shows the St. Helens Canal North site as closest to OV23 *Lolium perenne–Dactylis glomerata* community. The top three MAVIS results were also OV23 communities. OV23 is typical of unmanaged existing grassland developed on established soils. Both *Lolium perenne* and *Dactylis glomerata* do occur here but in very low abundance, although the site does have elements of OV23 such as the ruderal species present. MG1 *Arrhenatherum elatius* was the fourth result in MAVIS. *Arrhenatherum elatius* is a constant as is *Festuca rubra.* However *Arrhenatherum elatius* had very low cover values on the site and other, non-MG1 species were more abundant. The presence of many tree species as saplings also moves this community away from MG1. **St. Helens Canal North is classed as having affinities to OV23.**

2.3.2.27 St. Helens Canal South

TABLE 2.29 ST. HELENS CANAL SOUTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Eupatorium cannabinum	1	4	4	4	4	**V**
Holcus lanatus	1	4	1	4	2	**V**
Arrhenatherum elatius	5	4	4	4	1	**V**
***Betula pendula* (sap)**	4		4	1	5	**IV**
Buddleja davidii	8	5		1		**III**
Taraxacum officinale agg.	1	1		1		**III**
Linaria vulgaris	1		2	4		**III**
Salix caprea (sap)			4	1	4	**III**
Festuca ovina	1			1		**II**
Chamerion angustifolium	1				2	**II**
Hieraceum sp.	1	2				**II**
Epilobium palustre	1			1		**II**
Galium aparine		1			1	**II**
Agrostis stolonifera		1			4	**II**
Plantago lanceolata				1	1	**II**
Leontodon hispidus				1	1	**II**
Rubus fruticosus agg.	1					**I**
Sonchus oleraceus		1				**I**
Senecio viscosus		1				**I**
Senecio jacobaea			1			**I**
Tussilago farfara				1		**I**
Pteridium aquilinum				4		**I**
Cirsium arvense				1		**I**
Hypericum perforatum				1		**I**
Euphrasia officinalis				1		**I**
Pilosella officinarum				1		**I**
Epilobium montanum				1		**I**
Tragopogon pratensis				1		**I**
Plantago major				1		**I**
Erigeron acris				1		**I**
Trifolium dubium				1		**I**
Dactylis glomerata					2	**I**
Vulpia bromoides					1	**I**
Lapsana communis					1	**I**
Vicia sativa					1	**I**
Hypochaeris radicata					1	**I**
TOTAL SPECIES: 36	**12**	**10**	**7**	**23**	**15**	
Top four MAVIS results:	**FIT**					
OV23	**40.1**					
OV23d	**36.9**					
MG1a	**36.4**					
MG1b	**33.8**					

The St. Helens Canal South site was situated on flat ground in an urban setting, just south of the previous community. The community comprised tall vegetation near to the rails, mainly *Eupatorium cannabinum* and *Buddleja davidii*, with *Arrhenatherum elatius* growing towards the centre of the track. The average vegetation cover was 50%. A total of 36 species were recorded. This included four constants such as *Holcus lanatus* and *Betula pendula (*as saplings).

The CA shows the St. Helens Canal South plot as equidistant from MG1 *Arrhenatherum elatius* grassland and OV23 *Lolium perenne–Dactylis glomerata* community. The top MAVIS result for St. Helens Canal South was OV23. OV23d (*Arrhenatherum elatius–Medicago lupulina* sub-community), the second MAVIS result, appeared to be the better fit as this matched two constants at the St. Helens Canal South site; *Arrhenatherum elatius* and *Holcus lanatus.* MG1a and MG1b (*Festuca rubra* sub-community and *Urtica dioica* sub-community respectively) were the third and fourth MAVIS results. Having abundant *Arrhenatherum elatius* and *Holcus lanatus* is more characteristic of MG1 than OV23. However, the abundance of *Eupatorium cannabinum* (a constant species on this site) and *Buddleja davidii* (dominant in one relevé) does not fit with any existing MG1 sub-community. **St. Helens Canal South is classed as having affinities with MG1 but with ruderal species and *Buddleja davidii.***

2.3.2.28 St. Helens Link

TABLE 2.30 ST. HELENS LINK					
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**F**
Eupatorium cannabinum	5	5	5	5	**V**
Holcus lanatus	4	4	5	1	**V**
Agrostis stolonifera	4	7	4	1	**V**
Arrhenatherum elatius	4		1	2	**IV**
Festuca ovina	1	1	4		**IV**
***Rubus fruticosus* agg.**	1		5	4	**IV**
***Taraxacum officinale* agg.**	1	1	3		**IV**
Cerastium fontanum	1	1	1		**IV**
Sonchus asper	1		1	1	**IV**
Epilobium hirsutum	4			2	**III**
Vicia hirsuta	1		1		**III**
Ranunculus repens	1		1		**III**
Epilobium ciliatum	1		1		**III**
Plantago lanceolata	1	1			**III**
Lotus corniculatus	1	1			**III**
Trifolium dubium	1	1			**III**
Trifolium repens	1		4		**III**
Artemisia vulgaris		1	2		**III**
Equisetum arvense		1	4		**III**
Stachys sylvatica			1	1	**III**
Poa pratensis			1	1	**III**
Scrophularia nodosa			1	1	**III**
Lapsana communis	1				**II**
Crepis capillaris	1				**II**
Chamerion angustifolium	1				**II**
Galium aparine	1				**II**
Deschampsia cespitosa	1				**II**
Hypericum perforatum	1				**II**
Euphrasia sp.	1				**II**
Trifolium pratense	1				**II**
Sagina procumbens		1			**II**
Salix sp. (sap)		1			**II**
Plantago major		1			**II**
Betula pubescens (sap)		1			**II**
Salix caprea (sap)		1			**II**
Hypochaeris radicata		1			**II**
Centarium erythraea		1			**II**
Tussilago farfara		1			**II**
Medicago lupulina			7		**II**
Euphrasia confusa			5		**II**
Salix cinerea (sap)			4		**II**
Epilobium parviflorum			1		**II**
Oenanthe cambrica			1		**II**
Hieraceum sp.			1		**II**
Cirsium arvense			1		**II**
Buddleja davidii			1		**II**
Geranium robertianum			1		**II**
Rumex crispus				1	**II**

SPECIES/RELEVE	1	2	3	4	F
Lonicera pericyclamen				1	II
Solanum dulcamara				1	II
TOTAL SPECIES: 50	**25**	**19**	**27**	**13**	
Top four MAVIS results:	**FIT**				
OV23	**40.5**				
OV23c	**39.1**				
OV23d	**37.8**				
MG1	**32.8**				

The St. Helens Link line was situated on flat ground and surrounded by scrub, tall ruderal vegetation and backed onto industrial units. Taller vegetation such as *Eupatorium cannabinum* occurred near to the rails with shorter vegetation, including many ruderal species, towards the centre of the track. A total of 50 species were recorded including nine constant species. These included *Sonchus* asper, Agrostis *stolonifera* and *Cerastium fontanum.*

The CA shows the St. Helens Link plot as situated closest to MG1 *Arrhenatherum elatius* grassland. The top three MAVIS results were OV23 *Lolium perenne-Dactylis glomerata* communities. However, the OV23 community can be rejected because the St. Helens Link site did not support either *Lolium perenne* or *Dactylis glomerata.* MG1 was the fourth result in MAVIS and the site did support *Arrhenatherum elatius* as a constant species, albeit with low cover values. Of greater abundance was *Eupatorium cannabinum* (also a constant species), which no NVC communities which have as a constant. Other grass species did occur at the site and therefore the site does appear more as a grassland than any other category. **This community is classed as having affinities with MG1 but with *Eupatorium cannabinum* and ruderal species which do not fit any existing sub-community.**

2.3.2.29 Staveley North

TABLE 2.31 STAVELEY NORTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Linaria vulgaris	1	2	1	1	1	**V**
Deschampsia cespitosa	5	4	2	2	2	**V**
***Betula pendula* (sap)**	1	1		2	1	**IV**
Agrostis capillaris	2	1		1	1	**IV**
***Betula pubescens* (sap)**	1		1	1	1	**IV**
Vulpia bromoides	1		1	1	1	**IV**
Agrostis stolonifera	1		1	1	1	**IV**
Arrhenatherum elatius		4	1	1	2	**IV**
Epilobium parviflorum	1			1	1	**III**
Senecio jacobaea	1		1	1		**III**
Taraxacum officinale agg.	1		1		1	**III**
Chamerion angustifolium	2	1			1	**II**
Hypochaeris radicata	1			1		**II**
Sonchus asper	1	1				**II**
Equisetum arvense	4	4				**II**
Epilobium montanum		1			1	**II**
Holcus lanatus		2	1			**II**
Dactylis glomerata		1			1	**II**
Tanacetum vulgare			1	2		**II**
Epilobium palustre			1	1		**II**
Sagina procumbens			1	1		**II**
Convolvulus arvensis	1					**I**
Bryum argenteum	2					**I**
Ceratodon purpureus	2					**I**
Phalaris arundinacea		1				**I**
Hieraceum sp.		1				**I**
Reseda luteola			2			**I**
Barbula unguiculata			1			**I**
Pilosella officinarum				1		**I**
Scorzoneroides autumnalis				1		**I**
Leontodon hispidus				1		**I**
Catapodium rigidum				1		**I**
Plantago major				1		**I**
Festuca rubra					1	**I**
Trifolium pratense					1	**I**
Lolium perenne					1	**I**
Poa annua					1	**I**
TOTAL SPECIES: 37	**17**	**13**	**14**	**19**	**17**	
Top four MAVIS results:	**FIT**					
OV23d	**36.8**					
MG9b	**34.7**					
OV23	**34.5**					
MG9	**33.1**					

The Staveley North site was situated on flat ground surrounded by ex-industrial land (an ex-colliery) which had been remediated. The vegetation was dominated by grasses, with *Deschampsia cespitosa* being the most frequent species. Ruderal species were scattered across the ballast. Vegetation cover was, on average, 65%. In total, 37 species were recorded including eight constants. The constants all recorded low cover values and included *Vulpia bromoides*, *Agrostis capillaris* and *Linaria vulgaris*.

MAVIS identifies two NVC community types for Staveley North; OV23d *Lolium perenne–Dactylis glomerata* community and MG9 *Holcus lanatus–Deschampsia cespitosa* grassland. Only one constant from the assemblage at Staveley North; *Arrhenatherum elatius* characterises OV23, while *Lolium perenne* was scarcely present. Both *Arrhenatherum elatius* and *Deschampsia cespitosa* (the dominant species of the community) are constant here and are typical of MG9b. However the whole species assemblage is very difficult to place within the MG9 category reflecting that MG9 is a community of moist soils whereas Staveley North was free-draining. The CA shows Staveley North as equidistant from OV23 and MG1. The site is not similar to MG1 *Arrhenatherum elatius* grassland due to the low cover of *Arrhenatherum elatius* and the presence of constants such as *Linaria vulgaris* and *Betula pubescens* (as saplings). **Despite having elements of a number of communities, due to the combination of species present, the Staveley North community cannot be placed within an existing NVC category.**

2.3.2.30 Staveley South

TABLE 2.32 STAVELEY SOUTH						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
***Betula pendula* (sap)**	5	1	5	4	4	**V**
Deschampsia cespitosa	5	4	4	4	4	**V**
Holcus lanatus	4	4	4	4	2	**V**
Arrhenatherum elatius	4	4	5	4	2	**V**
Ceratodon purpureus	4	2	4	4	1	**V**
Epilobium palustre	1	1	1	1	1	**V**
Vulpia bromoides	4	1	2	2	2	**V**
Agrostis capillaris	4	1	1	4	4	**V**
Chamerion angustifolium	1	1	1	4	4	**V**
Plantago major	1	1	1	1	1	**V**
Anisantha sterilis	2	2	2	1	1	**V**
Senecio jacobaea	4	4	2	2	1	**V**
Epilobium parviflorum	1	1	1	1	1	**V**
Linaria vulgaris	1	4	4	4	1	**V**
Bryum argenteum	1	4		1	1	**IV**
Tanacetum vulgare	2		1	1	4	**IV**
Heracleum sphondylium	4	1	1	1		**IV**
***Taraxacum officinale* agg.**	1	1	1	1		**IV**
Equisetum arvense	4			1		**II**
Cirsium arvense	1	1				**II**
Sonchus asper	1			1		**II**
Bryum sp.	1			1		**II**
Leontodon autumnalis		2	1			**II**
Leontodon hispidus		1			1	**II**
Veronica arvensis		1		1		**II**
Betula pubescens (sap)			1		1	**II**
Epilobium montanum	1					**I**
Festuca ovina	1					**I**
Salix caprea (sap)	1					**I**
Hypochaeris radicata		1				**I**
Odontites vernus			1			**I**
Rubus fruticosus agg.			1			**I**
Cerastium fontanum				1		**I**
Trifolium pratense				4		**I**
Bellis perennis				1		**I**
Tussilago farfara				2		**I**
Alnus incana (sap)					4	**I**
TOTAL SPECIES: 37	**25**	**22**	**21**	**26**	**19**	
Top four MAVIS results:	**FIT**					
OV23d	**32.2**					
OV27	**30.9**					
W24	**30.6**					
MG1b	**30.5**					

The Staveley South site was situated on flat ground surrounded by ex-industrial land (an ex-colliery) which had been remediated. The vegetation was a mixture of tufted grasses growing throughout the ballast and low-growing herbaceous species. The vegetation covered, on average, 60% of the ballast. A total of 37 species were recorded including eighteen constant species. These included *Anisantha sterilis*, *Deschampsia cespitosa* and *Linaria vulgaris.*

The CA shows the Staveley South plot as equidistant from OV23 *Lolium perenne–Dactylis glomerata* community and MG1 *Arrhenatherum elatius* grassland. The top MAVIS result for Staveley South was OV23d (*Arrhenatherum elatius–Medicago lupulina* sub-community). OV23 can be rejected because neither *Lolium perenne* nor *Dactylis glomerata* were recorded at the site. OV27 *Epilobium angustifolium* is the second MAVIS result and this can be rejected because the Staveley South site was not dominated by *Chamerion (Epilobium) angustifolium*. Similarly, the third MAVIS result was W24 *Rubus fruticosus-Holcus lanatus* underscrub and this can be rejected due to the single specimen of Bramble that was recorded on the site. MG1b *Arrhenatherum elatius* grassland *Urtica dioica* sub-community, the fourth MAVIS result, matches *Arrhenatherum elatius* only as a constant. MG1e (*Centaurea nigra* sub-community) matched three constant species with Staveley South; *Arrhenatherum elatius*, *Holcus lanatus* and *Heracleum sphondylium.* However, within this site were a number of constant species which do not fit into any NVC community as constants, for example, the ruderals *Vulpia bromoides*, *Linaria vulgaris* and *Anisantha sterilis.* **Given the**

CA plot location and the species assemblage, this community is classed as having affinities with MG1 but with a marked ruderal component.

2.3.2.31 Trecwn East

TABLE 2.33 TRECWN EAST				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Hypericum tetrapterum	1	1	2	**V**
Arrhenatherum elatius	5	4	4	**V**
Geranium robertianum	4	4	6	**V**
Holcus lanatus	5	5	6	**V**
Polytrichum commune	5	7	4	**V**
Dactylis glomerata	1	1		**IV**
***Acer pseudoplatanus* (seedling)**	1		1	**IV**
Geum rivale	1	1		**IV**
Lolium perenne	4	2		**IV**
Epilobium ciliatum	1	1		**IV**
Calluna vulgaris	1	1		**IV**
Dicranium scoparium		5	4	**IV**
***Rubus fruticosus* agg.**		1	1	**IV**
Ulex gallii		1	1	**IV**
Sonchus oleraceus		1	1	**IV**
Thuidium tamariscinum	1			**I**
Eurhynchium praelongum	2			**I**
Rhododendron ponticum	1			**I**
Viola canina agg.		1		**I**
Dryopteris felix-mas		1		**I**
Primula vulgaris		1		**I**
Agrostis capillaris			1	**I**
Cladonia sp.			1	**I**
Angelica sylvestris			1	**I**
TOTAL SPECIES: 24	**14**	**17**	**13**	
Top four MAVIS results:	**FIT**			
MG9b	**26.9**			
MG1c	**24.4**			
MG1b	**23.9**			
OV23d	**23.8**			

The railway line at Trecwn East is situated in a cutting. One of the slopes is heavily wooded and the other comprises tall shrubs. This community is closed with a grass and bryophyte character with heathy elements. A total of 24 species were recorded, fifteen of which were constants. These included *Calluna vulgaris*, *Ulex gallii*, *Hypericum tetrapterum*, *Geranium robertianum* and *Geum rivale.* Four species of bryophyte were also recorded, two of which were constant. One of these, *Polytrichum commune*, is a dominant. Some of the constant species exhibited low cover values but the mean vegetation cover of the site was 90%.

The CA shows the Trecwn East plot as extremely isolated from any of the four NVC community plots. Similarly all MAVIS similarity scores are low, due to the combination of heathy, ruderal, grass and moss species. The top MAVIS result for Trecwn East was MG9b *Holcus lanatus–Deschampsia cespitosa* grassland *Arrhenatherum elatius* sub-community. However at Trecwn East, no *Deschampsia cespitosa* was recorded, which eliminates MG9. MG1c *Arrhenatherum elatius* grassland communities were the second and third MAVIS results and with *Arrhenatherum elatius* and *Dactylis glomerata* as constants the community does have features of MG1. However, the presence of *Calluna vulgaris* and *Ulex gallii* as constants are characteristic of H8 *Calluna vulgaris-Ulex gallii* heath. However, the Trecwn East community also supports rank grasses and lacks the acidic herbaceous species assemblage of H8. **The Trecwn East site has affinities with MG1 and H8 but is difficult to place within either community.**

2.3.2.32 Trecwn West

TABLE 2.34 TRECWN WEST						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Geranium robertianum	8	6	7	7	7	**V**
Holcus lanatus	5	4	2	5	6	**V**
Chamerion angustifolium	4	4	4	4	8	**V**
Epilobium ciliatum	4	4	2	4	4	**V**
Arrhenatherum elatius	5	5	5	5	5	**V**
Lolium perenne	1	1	1	4	4	**V**
Epilobium tetragonum	4	5		4	4	**IV**
Lotus corniculatus	4		4	8	6	**IV**
***Rubus fruticosus* agg.**	1	1		1	1	**IV**
Geum rivale	1		1	1	1	**IV**
Festuca rubra	2	1	1			**III**
Fragaria vesca	1	1	1			**III**
Lathyrus pratensis		1	1	1		**III**
Plantago lanceolata	2	1				**II**
Geranium molle	2	1				**II**
Calluna vulgaris		1			1	**II**
Bryum capillaire			1		1	**II**
Sonchus oleraceus			1		1	**II**
Vicia orobus				1	1	**II**
Prunella vulgaris				1	1	**II**
Trifolium dubium	2					**I**
Polytrichum commune		2				**I**
Agrostis capillaris			1			**I**
Pteridium aquilinum				1		**I**
Fraxinus excelsior				1		**I**
Quercus sp. (seedling)				1		**I**
Poa annua				1		**I**
Trifolium repens					4	**I**
Vicia bithynica					1	**I**
TOTAL SPECIES: 29	**15**	**15**	**14**	**17**	**17**	
Top four MAVIS results:	**FIT**					
MG1a	**35.4**					
MG1c	**34.3**					
MG9b	**34.0**					
OV27	**33.7**					

The site at Trecwn West was situated within a shallow cutting. One slope was wooded and the other slope was covered in Bramble scrub. The community comprised tall grass growing near to the rails with many leguminous species and few acid heath species. A total of 29 species were recorded with ten of these being constants. Constants included *Lotus corniculatus*, *Geranium* *robertianum*, *Chamerion angustifolium* and *Epilobium tetragonum. Calluna vulgaris* and *Pteridium aquilinum* both occurred in low densities here, giving the community a slight heath characteristic.

The CA shows the Trecwn West plot as nearest to OV38 *Gymnocarpietum robertianae* community. However, *Gymnocarpium robertianum* was not present within the community and OV38 occurs on limestone whereas Trecwn West is on ballast which had a heath element to it, hence this community can be discounted. The top MAVIS result for Trecwn West was MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community. *Arrhenatherum elatius* is the only constant that corresponded with MG1a. Similarly MG1c (*Filipendula ulmaria* sub-community) had few corresponding species although *Lathyrus pratensis* is frequent (III) within MG1c and was frequent at Trecwn West. MG9b *Holcus lanatus-Deschampsia cespitosa* grassland *Arrhenatherum elatius* sub-community was the third MAVIS result and this can be rejected due to the lack of *Deschampsia cespitosa* at the site. OV27 *Epilobium angustifolium* community was the fourth MAVIS result and *Chamerion angustifolium* was a constant here. However, it did not dominate the community which it does within OV27. The Trecwn West site had *Geranium robertianum* as a constant and this gives it an affinity with OV38 *Gymnocarpietum robertianae* community. OV38 has *Geranium robertianum* and *Arrhenatherum elatius* as constant species, as does Trecwn West. **The Trecwn West community has affinities to MG1 but cannot be placed within an existing NVC community due to the heath and ruderal nature character of the species assemblage.**

2.3.2.33 Wirksworth Quarry

TABLE 2.35 WIRKSWORTH QUARRY				
SPECIES/RELEVE	**1**	**2**	**3**	**F**
Epilobium montanum	4	2	1	**V**
Geranium robertianum	2	2	1	**V**
Holcus lanatus	1	1	1	**V**
***Taraxacum officinale* agg.**	1	1	1	**V**
***Rubus fruticosus* agg.**	4	1		**IV**
Poa annua	4	1	1	**IV**
Agrostis stolonifera	5	1	7	**IV**
Trifolium repens	1	1	1	**IV**
Geum urbanum	3	5	1	**IV**
Senecio jacobaea	1	2	1	**IV**
Sonchus asper	1	1	1	**IV**
Scrophularia auriculata	1	1	1	**IV**
Hypericum perforatum	1	1	3	**IV**
Lapsana communis		2	1	**IV**
Fragaria vesca		1	4	**IV**
Plantago lanceolata	1	1		**IV**
Rumex acetosa	3	2		**IV**
Leucanthemum vulgare	2	2		**IV**
***Hieraceum* sp.**	1		1	**IV**
Hedera helix	1	5		**IV**
Epilobium parviflorum	1	1		**IV**
Leontodon autumnalis	1	1		**IV**
***Betula* sp. (sap)**	1		1	**IV**
Ballota nigra	1		2	**IV**
Medicago lupulina		5	4	**IV**
Equisetum arvense		1	1	**IV**
Ranunculus acris		2	1	**IV**
Ranunculus repens		1	1	**IV**
Cardamine hirsutum	1			**II**
Dactylis glomerata	1			**II**
Juncus bufonius	5			**II**
Arrhenatherum elatius		4		**II**
Plantago major	1			**II**
Fraxinus excelsior		1		**II**
Heracleum sphondylium		2		**II**
Deschampsia flexuosa	1			**II**
Prunella vulgaris	1			**II**
Trifolium pratense	1			**II**
Juncus effusus	1			**II**
Juncus articulatus	1			**II**
Cerastium fontanum	1			**II**
Melilotus officinalis	1			**II**
Tripleurospermum inodorum	1			**II**
Epilobium sp.		1		**II**
Rosa sp.		2		**II**
*Helminthotheca echioides** (*Picris*)		1		**II**
Lolium perenne		2		**II**
Origanum vulgare			4	**II**

SPECIES/RELEVE	1	2	3	F
Viola sp.			5	II
Vicia sepium			2	II
Verbascum thapsus			1	II
Buddleja davidii			3	II
Sagina procumbens			2	II
Brachypodium sylvaticum			1	II
Cirsium vulgare			1	II
Veronica chamaedrys			1	II
Linaria vulgaris			1	II
Stellaria media			1	II
TOTAL SPECIES: 56	**34**	**32**	**32**	
Top four MAVIS results:	**FIT**			
OV23c	**36.9**			
OV23	**34.9**			
MG8	**34.1**			
MG4	**33.8**			

The Wirksworth Quarry line was situated within a shallow cutting. Tall vegetation grew near to the rails, such as *Scrophularia auriculata*, with shorter vegetation towards the centre. The vegetation covered 65% of the ballast. A total of 56 species were recorded from the site. Twenty-eight species were recorded as constants including *Epilobium montanum*, *Scrophularia auriculata*, *Geranium robertianum* and *Lapsana communis.* All were recorded with low Domin scores. *Agrostis stolonifera* was also a constant and had the highest Domin score of 7 in one quadrat.

The top two MAVIS results for Wirksworth Quarry were OV23c *Lolium perenne–Dactylis glomerata* communities. This community is unlikely because neither *Dactylis glomerata* nor *Lolium perenne* were constant in this community and only two constants matched OV23; *Taraxacum officinale* agg. and *Trifolium repens.* The remaining MAVIS suggestions, MG8 *Cynosurus cristatus-Caltha palustris* grassland and MG4 *Alopecurus pratensis-Sanguisorba officinalis* grassland can both be rejected due to the lack of title species at the site. The CA plot is close to W24 *Rubus fruticosus-Holcus lanatus* underscrub and this is a closer match due to the presence of *Rubus fruticosus* agg. in greater abundance than any of the grass species. *Holcus lanatus* is also a constant species. However, the species combination across the whole site differs to that of W24 due to the high number of ruderal species present. **The Wirksworth Quarry site is classed as W24 with many ruderal species.**

2.3.2.34 Woodthorpe Colliery

TABLE 2.36 WOODTHORPE COLLIERY						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
Arrhenatherum elatius	5	4	6	6	5	**V**
Equisetum arvense	2	1		1	1	**V**
Linaria vulgaris	2	2			2	**V**
Epilobium montanum		1	2	2	1	**V**
Rubus fruticosus agg.	4		4	4		**III**
Taraxacum officinale agg.	1			1	1	**III**
Bryum sp.		1	1		1	**III**
Chamerion angustifolium		1	1		2	**III**
Fraxinus excelsior (sap)	4					**I**
Anisantha sterilis	2					**I**
Quercus robur (sap)		2				**I**
Holcus lanatus		4				**I**
Lolium perenne			2			**I**
Calystegia sepium			1			**I**
Sonchus asper			2			**I**
Hypericum perforatum			1			**I**
Festuca rubra				1		**I**
Tanacetum vulgare					1	**I**
Epilobium parviflorum					2	**I**
TOTAL SPECIES: 19	**7**	**8**	**9**	**6**	**9**	
Top four MAVIS results:	**FIT**					
OV27	**31.4**					
MG1a	**30.4**					
MG1b	**29.8**					
W24	**28.0**					

The Woodthorpe Colliery site was situated in a slight cutting approximately 1 metre deep with gently sloping sides. It was surrounded by arable land. The granite ballast was very deep with *Arrhenatherum elatius* and Bramble encroaching across it. Vegetation cover was, on average, 40%. A total of 19 species were recorded, including four constants. These included the ruderals *Linaria vulgaris* and *Equisetum arvense. Arrhenatherum elatius* is the dominant species in this community

The CA shows the Woodthorpe Colliery plot as almost equidistant to MG1 *Arrhenatherum elatius* grassland and W24 *Rubus fruticosus-Holcus lanatus* underscrub which also feature on the MAVIs results. The top MAVIS result for Woodthorpe Colliery was OV27 *Epilobium angustifolium* community. MG1a and MG1b (*Festuca rubra* sub-community and *Urtica dioica* sub-community respectively) were the second and third MAVIS results. The site did support abundant *Arrhenatherum elatius* and other grasses with lower abundances. W24 was the fourth MAVIS result. The site did support *Rubus fruticosus* agg. and *Holcus* lanatus, albeit with low cover values plus tree species, present as saplings, also occurred. **Given the greater abundance of *Arrhenatherum elatius*, Woodthorpe Colliery is classed as having affinities with MG1 but with ruderal species.**

2.3.2.35 Woodthorpe Colliery Junction

TABLE 2.37 WOODTHORPE COLLIERY JUNCTION						
SPECIES/RELEVE	**1**	**2**	**3**	**4**	**5**	**F**
***Betula pendula* (sap)**	4	4	2	2	1	**V**
Tanacetum vulgare	4	4	5	4	2	**V**
Hieraceum sp.	1	4	1	1	2	**V**
Epilobium montanum	2	1	1	1	1	**V**
Vulpia bromoides	4	4	4	4	4	**V**
Dactylis glomerata	2	2	4	2	2	**V**
Festuca rubra	4	4	2	4	2	**V**
Chamerion angustifolium	2	4	1	2	1	**V**
Linaria vulgaris	2	2	2	2	2	**V**
Sonchus asper	1	1	1	1	1	**V**
Epilobium parviflorum	1	1	1	1	1	**V**
***Rubus fruticosus* agg.**	2	1	4	2	4	**V**
Holcus lanatus	4	2	2	2		**IV**
Cirsium arvense	1	2	1		1	**IV**
***Bryum* sp.**	1	1		1	1	**IV**
Echium vulgare	2	2		4	4	**IV**
Reseda luteola	4	5	4		4	**IV**
***Taraxacum officinale* agg.**		1	1	1	1	**IV**
Plantago major		1	2	2	1	**IV**
Arrhenatherum elatius		2	2	2	1	**IV**
Verbascum thapsus		4	4	4	4	**IV**
Agrostis capillaris	4			2	1	**III**
Hypericum perforatum	2	2		1		**III**
Cirsium vulgare	2	1	1			**III**
Potentilla reptans	1	1	1			**III**
Lactuca serriola		2		1	2	**III**
Epilobium palustre		1		1	1	**III**
Fraxinus excelsior (sap)	1	1				**II**
Centaurea nigra	4	4				**II**
Helminthotheca echioides	1		2			**II**
Linum catharticum	1		1			**II**
Bryum argenteum	1			1		**II**
Erigeron acris	2		2			**II**
Heracleum sphondylium		1	1			**II**
Deschampsia cespitosa			1		1	**II**
Epilobium hirsutum			1		1	**II**
Equisetum arvense				1	1	**II**
Sonchus oleraceus	1					**I**
Artemisia vulgaris	1					**I**
Salix cinerea (sap)		1				**I**
Crataegus monogyna (sap)		1				**I**
Cerastium fontanum			1			**I**
Quercus robur (sap)			1			**I**
Pilosella officinarum			1			**I**
Trifolium pratense			2			**I**
Medicago lupulina			1			**I**
Conyza canadensis			1			**I**
Veronica arvensis				1		**I**

SPECIES/RELEVE	1	2	3	4	5	F
Urtica dioica					1	I
Hypericum humifusum					1	I
Leontodon hispidus					1	I
Betula pubescens (sap)					1	I
Geranium robertianum					1	I
TOTAL SPECIES: 53	**29**	**31**	**33**	**26**	**31**	
Top four MAVIS results:	**FIT**					
OV23d	**33.6**					
W24	**32.0**					
MG1a	**31.8**					
MG1	**31.5**					

The Woodthorpe Colliery Junction site was situated on a slight embankment, surrounded by arable farmland. The granite ballast was deep and open, with tufted vegetation and taller grasses growing closer to the rails. The average vegetation cover was 50%. A total of 53 species were recorded, with many species typical of ruderal habitats such as *Erigeron acris* and *Conyza canadensis.* There were 21 constant species, including *Tanacetum vulgare*, *Echium vulgare*, *Linaria vulgaris* and *Reseda luteola.*

The CA shows the Woodthorpe Colliery Junction plot as equidistant from OV23 *Lolium perenne–Dactylis glomerata* community and MG1 *Arrhenatherum elatius* grassland but some distance from either. These communities also feature in the MAVIS results. The top MAVIS result for Woodthorpe Colliery Junction was OV23d (*Arrhenatherum elatius–Medicago lupulina* sub-community)*.* *Dactylis glomerata* is present as a constant with low cover values but OV23 is typical of unmanaged but established grasslands which is not similar to the community at Woodthorpe Colliery Junction. W24 *Rubus fruticosus-Holcus lanatus* underscrub was the second MAVIS result. Both title species were present but with very low cover values. Tree species, present as saplings, also occurred in low numbers across the ballast. The number of grass species, however, and their combined abundance, identify this community as closest to a grassland. MG1 is a better match than W24 due to the presence of seven species of grass and the tall Umbellifer *Heracleum sphondylium.* However, this community has many ruderal constants, which do not fit descriptions of MG1. **The Woodthorpe Colliery Junction site is classed as having affinities to MG1 but with many ruderal species.**

Table 2.37 below gives an overview of the results from each site.

TABLE 2.38 NVC RESULTS PER COMMUNITY	
Community name	**Decision**
Amlwch	Affinities to MG1 but lacking Umbellifers
Appleby Embankment	Nil
Appleby Shaded	Nil
Appleby Wet	Nil
Blaenau Ffestiniog Cutting	Affinities to W24, with acidic and non-native species
Blaenau Ffestiniog Embankment	Affinities to MG1 with heath species
Blaenau Ffestiniog Open	Nil
Cambridge	OV23d
Carrington	Affinities to MG1 with ruderal species
Fleetwood North	MG1a
Fleetwood South	Affinities to MG1 with ruderal species
Gobowen – Oswestry	Affinities to MG1 with ruderal species + W24 element
Golborne Ash	W24b
Golborne North	W24b
Golborne Sidings	MG1a
Golborne South	W24b
Histon – St. Ives East	Nil
Histon – St. Ives West	Nil
Leek - Cauldon Quarry	Affinities to MG1 & W24 but lacking constant species
Leek – Cauldon Quarry Wooded	Affinities to W24
Leek - Stoke	Nil
Newport – Ebbw Vale	Affinities to W24 and MG1
Oswestry North Embankment	Affinities to W24 with Buddleja
Runcorn Docks	Affinities to MG1 with ruderal species
St. Helens Acid Works	Affinities to MG1 & W24 but open & with *Eupatorium cannabinum*
St. Helens Canal North	Affinities to OV23
St. Helens Canal South	Affinities to MG1 with ruderal species (incl. much Buddleja)
St. Helens Link	Affinities to MG1 with ruderal species & Buddleja
Staveley North	Nil
Staveley South	Affinities to MG1 with ruderal species
Trecwn East	Affinities to MG1 & H8
Trecwn West	Affinities to MG1 with heath species
Wirksworth Quarry	Affinities to W24 with ruderal species
Woodthorpe Colliery	Affinities to MG1 with ruderal species
Woodthorpe Colliery Junction	Affinities to MG1 with ruderal species

2.4 DISCUSSION

Each railway community was unique in its species composition and relative abundance. Most assemblages were difficult to assign to published NVC communities.

Both the ‘objective’ approaches (MAVIS and CA) present problems. MAVIS results are based on a Similarity Co-efficient which uses presence-absence only. Hence the frequency of each species remains unutilised with this method. CA does use species frequency but omits extent of coverage in each relevé. Both frequency of occurrence and coverage per relevé are important components of phytosociology. Consequently before allocating communities, the phytosociological descriptions and floristic tables needed to be carefully considered. This is borne out by the CA location of the Leek to Stoke plot which, after analysing the NVC table and site description, appears to be incorrectly placed.

Once this was done eight communities were identified that bear no relationship to published NVC communities (Appleby Embankment, Appleby Shaded, Appleby Wet, Blaenau Ffestiniog Open, Histon to St. Ives East, Histon to St. Ives West, Leek to Stoke and Staveley North). Most of these eight communities missed key components of an existing NVC community (e.g. all of the Appleby communities did not support *Rubus fruticosus* agg. or *Arrhenatherum elatius*). Many of them supported abundant bryophytes, which are under-sampled in the NVC. All of the eight communities supported combinations of ruderal species, including many as constants, which are currently undescribed. Others, such as Blaenau Ffestiniog Open supported a dominant species that does occur as a dominant in any similar NVC community, in this case *Molinia caerulea.* Histon to St. Ives East and Histon to St. Ives West are similar in that they support many ruderal species, some non-natives and an element of calcareous species. Leek to Stoke is a unique site in that it is very species-rich in comparison to the other sites and supports many tall herbaceous species and ruderals. Rodwell *et al* (2000) attempted to address the perceived gaps within the NVC. None of these eight sites match the communities predicted within this work.

These apparently unique communities may have equivalents described on the continent which will be the subject of the next chapter. Rodwell *et al* (2000) recognised that some communities may fall under the continental *Sisymbrion officinalis* type communities. It was suggested that a similar NVC community would include *Conyza canadensis*, *Sonchus oleraceus* and *Lactuca serriola.* No railway community had all of these species in combination but some of the unattributable communities had them as constants (e.g. Cambridge - *Conyza canadensis*, Appleby Embankment and Appleby Shaded - *Sonchus oleraceus;* Histon to St. Ives West - *Lactuca serriola).*

By comparison six communities could be clearly ascribed to published NVC descriptions. There are three sites which are ascribed to W24b *Rubus fruticosus–Holcus lanatus* underscrub *Arrhenatherum elatius–Heracleum sphondylium* sub-community (Golborne Ash, Golborne North and Golborne South). There are two representatives of the MG1a *Arrhenatherum elatius* grassland *Festuca rubra* sub-community (Fleetwood North and Golborne Sidings) and one OV23d *Lolium perenne–Dactylis glomerata* community *Arrhenatherum elatius–Medicago lupulina* sub-community (Cambridge).

Additionally there are twenty-one communities that contain key elements of published NVC communities that also possess significant differences. Twelve of these have an affinity to MG1 (see Table 2.38). These typically possess *Arrhenatherum elatius* alongside other grassy components. They are distinct from MG1 in that they contain ruderals as constants and lack forbs common to MG1 (usually the large Umbellifers). Another group akin to MG1 possess a heathy component usually alongside the grasses and some ruderals. A further four sites have communities with key features of W24 with additional species constant not previously described. These are typically ruderals although *Buddleja davidii* is a significant component of some communities. Four locations have assemblages with features of both MG1 and W24 communities. One location, St. Helens Canal North, has affinities to OV23 but the typical OV23 habitat does not fit with the site.

Whether these twenty-one communities can be attributable to either MG1 or W24 depends upon the breadth of circumscription of these two communities and the means by which they are distinguished from each other given that they form a successional sequence (Rodwell, 1992). Both MG1 and W24 are extremely broad and rarely studied communities. MG1 is the sole lowland ungrazed mesotrophic grassland described in the NVC and lacks a comprehensive description although comparable communities have long been recognised on the continent (e.g. Tuxen, 1955; Pfitzenmeyer, 1962). Although Rodwell (1992) in his account of the MG1 community recognises its occurrence on industrial habitats such as building sites, the physiognomic and habitat descriptions are based upon typically closed communities on relatively rich soil. Hence a common feature of the community as described are tall Umbellifers with the closed sward severely limiting the occurrence of ruderals. By comparison the communities surveyed in this study are open, allowing abundant ruderals with the open, free-draining substrate limiting the colonisation of more nutrient demanding species. This raises the question of whether the communities described here akin to MG1 are part of a ruderal sub-community of MG1, previously undescribed or represent a new *Arrhenatheretum*. Where *Arrhenatherum elatius* is not dominant but a rank sward supports abundant *Holcus lanatus* and *Festuca rubra*, Rodwell *et al* (2000) recognised that this may also need a community description. In addition, where dominant species were found which are not dominant in any NVC community, such as *Eupatorium cannabinum* at the St. Helens Link site, the question remains as to whether they represent a new community or again, a new sub-community of the *Arrhenatheretum.*

Similar problems exist with the characterisation of W24. W24 is typically described as a closed community and the question is whether the open *Rubus fruticosus* agg. dominated communities recorded in this study fall within the W24 community or represent a distinct phytosociological association.

A further confusing factor is the floristic closeness of MG1 and W24. Both can possess *Arrhenatherum elatius* and *Rubus fruticosus* agg. with abundances overlapping. Rodwell (1992) describes a succession from an MG6 *Lolium perenne-Cynosurus cristatus* grassland, a moderately species rich typically grazed grassland, which then has grazing removed. This results in the dominance of *Arrhenatherum elatius* with an MG1 the result. Further neglect allows Bramble to become dominant producing the W24 community. A similar successional sequence is also described starting from an OV23d *Lolium perenne–Dactylis glomerata* community, a close sward community of resown verges and fields which, if cutting ceases, may become MG1 with W24 to follow. So an additional problem is where the MG1 (or MG1–like) community ends and W24 (or W24-like) community begins.

The stand analysis has cut off a small eutrophic group (Group 1) and then split the remainder between a more colonising Group 00 and a more colonised Group 01. Group 00 splits into two distinct groups with 000 appearing transitional with 01 and 001 more extreme. Where *Arrhenatherum elatius* is an indicator species it is found with a mix of species typical of either scrub or open ruderal vegetation. Thus supporting the analysis elsewhere. The Ellenberg and CSR analysis sheds little light on the community differentiation. This is addressed by a more sophisticated analysis in Chapter 4.

If one examines the variation between other NVC communities where a single species is dominant across a number of communities, for instance W10, W11, W16 and W17 are all Quercus woodlands while MG5 and MG6 are both Cynosurus grasslands, it is the associated vegetation and its physiognomy that merit differentiation. Given the associated species with A. elatius are very different from that described by Rodwell (1992) for MG1, with short lived ruderal species rather than perennials, and that the physiognomy is also markedly different, an open dynamic community rather than a closed one, I consider that the community described here constitutes a new Arrhenatheretum, previously undescribed from the UK.

CHAPTER 3 – A PHYTOSOCIOLOGICAL INVESTIGATION OF BRITISH DISUSED RAILWAY BALLAST VEGETATION USING THE BRAUN-BLANQUET SYSTEM

3.1 INTRODUCTION

Josias Braun-Blanquet started his phytosociological career studying alpine vegetation and published this work in 1913. The Braun-Blanquet (hereafter known as Br-Bl) methodology was developed by experienced plant ecologists, including Br-Bl himself. They had vast knowledge of the communities present in their region of study due to years spent surveying the land. From 1913 onwards, Br-Bl published prolifically in various Swiss publications (e.g. Br-Bl, 1915 and Br-Bl, 1931). Br-Bl's seminal work *Pflanzensoziologie* in 1928 cemented the Zurich-Montpelier (Z-M) approach.

Br-Bl developed the idea of associations based purely on floristic composition. He gave little weight to the dominance of each species and the physiognomy of the community. Only after careful and thorough surveys of the same community from a whole region, can the association be formed. The association is a hierarchical system of alliance, order and class, each formed from species found only within each community.

There are basically five steps to the original Br-Bl methodology:

1) Field description: determining a homogenous plant community in the field and amassing the species lists from a minimum area relevé. Each species is assigned an abundance score and a sociability score. However, sociability (a measure of the extent of clustering) has more or less been discarded by modern phytosociologists. This is due to three

key factors; the subjectivity of the score assigned to the species (which depends largely on substrate), the lack of suitable statistical determination of sociability and the fact that sociability represents the growth form of the species, not its social physiognomy.

2) Aggregation of data into tables. The species lists would be copied by hand and sorted by hand over many tables until patterns emerged of groups of species always occurring together. Eventually an association table was produced.

3) Using prior knowledge to check the species list against factors such as environmental features (same soil type, aspect etc.).

4) Surveying for similar communities in the region.

5) Constructing an association table using all the available data from a habitat.

A hierarchical system would emerge with the association with its faithful species, followed by alliance, order and class. Despite the aggregation of data into a table being relatively simple, the final analysis of the association table required a level of knowledge of the plant community studied and the locality. A criticism of the Br-Bl method was based upon the subjective nature of some of this process (Shimwell, 1971).

One of the key features of the Br-Bl system is the concept of ‘faithful species’; that is a species which occurs within one community and no other and often referred to as fidelity. “Fidelity is the most fundamental notion of the Br-Bl approach…it is also the concept through which (the Br-Bl school) differs from all other schools of vegetation science” (Barkman, 1989). Poore (1955a, 1955b, 1955c & 1956) published a series of criticisms of the method, as he attempted to apply it to British vegetation. Considering plant communities to be fluid, he discarded the fidelity concept, explaining that a species could occur within a continuum of communities. Similarly, continental ecologists applying Br-Bl methods to their locality, without having the extensive plant geographical knowledge of their region which the Br-Bl method requires, found the same fidelity species in a number of plant communities (Shimwell, 1971).

However, fidelity continues to be a key component of phytosociological work (e.g. Bruelheide, 2000). The modern approach is to address fidelity with statistical analysis (e.g. Lososová *et al*, 2006 and Willner *et al*, 2009).

Following the International Botanical Congress in 1950, the Z-M system was formally adopted as the recognised method for continental phytosociologists. Consequently, most of Europe continued to, or started to, use Br-Bl’s method for describing their vegetation e.g. Passarge (1957), Poore & McVean (1957), Werger (1973) and Mirkin & Naumova (2009). Currently, the methodology is used throughout continental Europe (Chytrý & Tichý, 2003, Favero-longo *et al*, 2006 and Mirkin & Naumova, 2009). Further afield, Br-Bl is also chosen as a method of vegetation classification with recent studies on Ethiopian riverine habitats (Tikssa *et al*, 2009), Iranian woodlands (Hamzeh’ee *et al*, 2008) and Californian sand dunes (Biondi & Cassavechia, 2001).

British ecologists have diverged from continental approaches, typically following the views of Clements (1905) and others (Tansley, 1904 and Moss, 1910), who argued that the association, of 'formation' as they preferred to call it, was not abstract but a successional entity. The plant community constantly changed along seres before reaching a climax. Therefore, whilst the continental ecologists were placing emphasis on a unit of pure vegetation, British ecologists preferred geographical descriptions instead such as aspect, slope etc.

In recent years, software has been developed to enable the relevés to be entered, sorted and analysed. Turboveg (Hennekens & Schaminee, 2001) was developed as a database to store multiple relevés. JUICE (Tichy, 2002) was then created to work alongside Turboveg and analyse the data using a variety of ordination packages such as COCKTAIL and TWINSPAN. Most modern phytosociological work uses both Turboveg and JUICE e.g. Knollová *et al* (2006), Šilc & Košir (2006), Cimalová & Lososová (2009) and Nowak *et al* (2014a). However, Turboveg and JUICE are difficult to use in the UK. No British ecologists appear to have used them and the inherent layout and choices of nomenclature are aimed at continental relevés. Moreover, the software packages cannot be used across countries, for example, to compare datasets from different countries. The UK has never set up a database of phytosociological relevés. Hence UK phytosociological studies use alternative databases and methods of analysis (e.g. MAVIS).

Most of the early phytosociological work, both on the continent and in Britain, took place in semi-stable habitats or semi-natural habitats, such as mountain ranges, permanent grasslands or heathland (Shimwell, 1968). As the interest in synanthropic vegetation developed, many were sceptical as to whether Br-Bl could be used in disturbed habitats. For instance, Poore (1955) stated that ‘new’ habitats will not support faithful species and therefore they cannot be formed into associations. Likewise, Pott (1992) considered that only well developed communities could be classified into an association or sub-association, ‘developing’ and ‘degenerated or regenerated’ communities were impossible to classify.

By comparison, other authors believed that it was possible to classify synanthropic vegetation. Becking (1957) considered that the advantage of the Br-Bl methodology is that it could be used on ‘artificial, disturbed and successional vegetation’, although requiring that the plant community must have reached a ‘temporary equilibrium’. Communities such as the *Sisymbrion* and *Tanaceo-artemisietum* were only ever described from urban environments in Central Europe (Sukopp & Werner, 1983). Shimwell (*in litt.* 2006) always believed that Br-Bl would work on new vegetation.

Br-Bl has been frequently used on the continent to classify synanthropic vegetation. For example, on weed and trampled vegetation the Czech Republic (Lososová & Simonová, 2008 and Simonová, 2008), pioneer vegetation on an asbestos mine in Italy (Favero-longo *et al*, 2006), vegetation establishment on a marble quarry in Italy (Gentili *et al,* 2011) and city vegetation in Slovenia (Šilc & Košir, 2006). Ecologists further afield have also used the Br-Bl methodology in similar habitats e.g. Tikssa *et al* (2009) studied plant communities of river corridors in Ethiopia and Nowak *et al* (2014b) described weed associations from arable land in Krygyastan, Asia.

In contrast, few British ecologists have published work on urban or synanthropic phytosociological communities. Hepburn (1942) described the plant assemblages of the Barnack stone quarries. A study of the plant colonisation of lime beds in Cheshire was undertaken by Lee & Greenwood (1976). Silverside (1977) studied the phytosociology of British arable weeds. Shaw (1992) described the plant colonisation and long-term plant communities of pulverised fuel ash (PFA). Wright and Wheater (1993) surveyed the vegetation on a disused railway line in Derbyshire. There have been no recent peer-reviewed phytosociological studies of synanthropic vegetation in the UK. This is reflected in the lack of publications in journal databases (e.g. Web of Science). This study, therefore, is a unique combination of a phytosociological approach to UK synanthropic vegetation using the Br-Bl methodology.

The aim of this chapter is to identify disused railway ballast communities using a modified Br-Bl approach. A comparison will be made to the National Vegetation Classification (NVC) communities described in Chapter 2.

3.2 METHODS

3.2.1 Site selection

Sites were chosen for the presence of disused track with the rails *in situ*, and therefore ballast also still intact. The railways also had to possess vegetation so therefore had to have been abandoned for a minimum amount of time, usually two years. The vegetation needed to support mainly ruderal plant species and therefore, was generally in the early stages of succession; disused lines which were heavily wooded or supported significant coverage of scrub were not sampled (for example, sites dominated by *Rubus fruticosus* agg. were often impenetrable so were not sampled). Moreover, heavily wooded sites with rails *in situ* were rare. Sites were also chosen for convenience of access, safety and initial broad geographic spread although this was tempered by availability. Many of the disused lines were located in ex-industrial areas with little pressure for development on the land. Others were rural routes which served now defunct collieries or power stations. The locations were selected by firstly finding disused railways (Baker 2004, 2010) and OS paper maps. Aerial photography via Google earth and internet searches were then used to determine whether track was still *in situ*. If a disused track was very close to a live line it was not visited for health and safety reasons. Details of sites surveyed are listed in table 1 below.

3.2.2 Sampling

At each site an approximately homogenous vegetation type was identified by eye and surveyed using up to 10 relevés. The number of each relevé at each site was restricted by the extent of the community present. Thus the survey method is distinct from that in the previous chapter.

The maximum size of relevé needed to efficiently survey the vegetation was found along the chosen homogenous stretch of railway line. The minimum area calculation was used. In disused railway lines the vegetation typically grows in the gaps between the sleepers so each relevé was approximately 1.4 metres wide and between 3 metres to 10 metres in length. This lends itself well to the Br-Bl approach, which has no fixed relevé size, rather the relevé size is incrementally increased until no new species are recorded. Vegetation was recorded in two sleeper gaps initially with additional sleeper gaps being added as long as any new plant species were found (i.e. increasing the size of the relevé by one sleeper gap each time). Once no new plant species were found then this was determined to be the maximum size of relevé needed. The relevé size was determined afresh at each sample.

At each site all of the plants within the relevé were identified. A percentage cover value of between 1%-100% was estimated for each species. The traditional Br-Bl approach is to score each species along a six point abundance score. However, percentage cover maintains detail and allows potentially more discriminating computer analysis.

A field-recording sheet was created to input the raw data during the surveys. An example is included in Chapter 2. The raw data for the Br-Bl analysis was collected separately from the NVC data of Chapter 2. A sketch of the railway line was added to the field sheet to aid visualising the railway during the write-up.

In all cases, if plants, particularly lower plants, could not be identified in the field then a sample of the plant was bagged and taken back to identify in more detail (i.e. with a microscope and relevant keys). Vascular plants were named following Stace (2010) and bryophytes using Smith (2004).

176 relevés were taken from a total of 35 sites from 22 different railway lines (see Table 3.1).

TABLE 3.1 LIST OF RAILWAY LINE SITES SURVEYED					
SITE CODE	**SITE**	**GRID REFERENCE**	**VICE-COUNTY**	**NO OF RELEVES**	**DATE SURVEYED**
AM	Amlwch	SH 424913	52	5	16/07/2009
APC	Appleby Cutting	NY 694200	69	4	13/07/2009
APE	Appleby Embankment	NY 696195	69	4	13/07/2009
APW	Appleby Wet	NY 694199	69	3	13/07/2009
BFC	Blaenau Ffestiniog Cutting	SH 705441	48	6	16/09/2009
BFE	Blaenau Ffestiniog Embankment	SH 707439	48	5	16/09/2009
BFO	Blaenau Ffestiniog Open	SH 704443	48	3	16/09/2009
CA	Cambridge	TL 428639	29	5	23/08/2004
CN	Carrington	SJ 753903	58	10	04/05/2007
FN	Fleetwood North	SD 328457	60	5	07/07/2009
FS	Fleetwood South	SD 342428	60	5	07/07/2009
G-O	Gobowen – Oswestry	SJ300313	40	5	17/07/2009
GA	Golborne Ash	SJ 603993	59	3	03/08/2009
GN	Golborne North	SJ 602991	59	5	03/08/2009
GSI	Golborne Sidings	SJ 603989	59	6	04/08/2004
GS	Golborne South	SJ 601988	59	5	03/08/2009
H-ST.IE	Histon – St. Ives East	TL 397681	29	3	21/07/2007
H-ST.IW	Histon – St. Ives West	TL 363694	29	5	21/07/2007
L-C	Leek – Cauldon Quarry	SK 022538	39	10	12/05/2005
L-CW	Leek – Cauldon Quarry Wooded	SJ 996545	39	3	12/05/2005
L-S	Leek – Stoke	SJ 939538	39	6	04/05/2005
N-EB	Newport – Ebbw Vale	ST 210965	41	3	22/06/2007
ONE	Oswestry North Embankment	SJ 297302	40	5	17/07/2009
RD	Runcorn Docks	SJ 499823	58	10	23/07/2009
ST.HA	St. Helens Acid Works	SJ 527938	58	5	29/07/2004
ST.CANN	St. Helens Canal North	SJ 515950	59	5	06/07/2009
ST.CANS	St. Helens Canal South	SJ 517949	59	5	06/07/2009
ST.HL	St. Helens Link	SJ 527939	58	4	21/06/2004
SN	Staveley North	SK 440741	57	5	22/08/2009
SS	Staveley South	SK 442739	57	5	22/08/2009
TE	Trecwn East	SM 963324	45	3	10/09/2010
TW	Trecwn West	SM 956320	45	5	10/09/2010
WQ	Wirksworth Quarry	SK 288545	57	4	18/07/2004
WC	Woodthorpe Colliery	SK 459744	57	5	13/08/2009
WCJ	Woodthorpe Colliery Junction	SK 456742	57	5	13/08/2009

3.2.3 Statistical Analysis

The survey results were entered into Excel. The software program R was used to undertake multivariate analysis of all 176 relevés. This incorporated both PCA analysis and NMDS. In addition, Ward's hierarchical cluster analysis was carried out (Ward, 1963), which is widely used for this type of data (e.g. Lososová *et al*, 2006).

For PCA and NMDS, all of the data was included. In addition, the data was run with the exclusion of species found in both less than 10% of the relevés and less than 20% of the relevés. PCA was also undertaken with and without the Hellinger transformation.

Following cluster analysis, species characteristic of each cluster were identified using Indicator Values (IndVal, Dufrene and Legendre, 1987). This assigns a value (max of 1.00) for each species, taking into account its exclusivity (its faithfulness to a cluster) and its fidelity (the extent to which it is found within a cluster). A value of 1 shows that a species is only found in a single cluster and is found in all the relevés within that cluster. The statistical significance of each IndVal is calculated based upon a randomization approach. A significant IndVal greater than or equal to 0.400 was taken as a species that can be used to characterize that cluster.

3.3 RESULTS

3.3.1 General

A total of 246 species were recorded across all of the sites using the Br-Bl method. Relevé size varied between 3 and 13 sleeper gaps. The mean relevé size was 10 sleeper gaps. The minimum number of relevés on any site was 3.

64 species are restricted to just one site. Table 3.2 shows the data for the species present in twenty or more relevés. *Arrhenatherum elatius, Rubus fruticosus* agg., *Holcus lanatus* and *Festuca rubra* were the most abundant species, each occurring in at least 50% of relevés. The mean coverage per relevé in which a species is present is typically low with the most widespread species (*Arrhenatherum elatius*) showing the highest value (15%). All other species have a mean % cover of 11% or less.

Table 3.2 Species present in 20 or more relevés, proportion of relevés present and mean and standard deviation of % cover in relevés present				
Species	**Number relevés present**	**% Relevés present**	**Mean % coverage**	**St.dev % coverage**
Arrhenatherum elatius	134	76	15	14
Rubus fruticosus agg.	102	58	9	8
Holcus lanatus	88	50	5	6
Festuca rubra	81	45	9	13
Taraxacum officinale agg.	80	45	2	1
Senecio jacobaea	72	41	2	2
Chamerion angustifolium	63	36	2	2
Dactylis glomerata	60	34	4	6
Epilobium montanum	57	32	1	1
Agrostis capillaris	52	30	2	2
Brachythecium rutabulum	48	27	5	6
Epilobium parviflorum	48	27	1	1
Lolium perenne	41	23	6	9
Sonchus asper	36	20	2	1
Geranium robertianum	35	20	9	18
Plantago lanceolata	35	20	2	3
Vulpia bromoides	31	18	11	12
Linaria vulgaris	29	16	2	2
Agrostis stolonifera	26	15	6	11
Fraxinus excelsior	26	15	9	13
Heracleum sphondylium	26	15	2	2
Betula pendula	23	13	6	7
Urtica dioica	22	12.5	1	0
Plantago major	22	12.5	1	1
Crataegus monogyna	22	12.5	1	1
Leontodon hispidus	21	12	2	2
Geum urbanum	21	12	3	3
Galium aparine	21	12	1	0
Poa annua	21	12	2	2
Deschampsia cespitosa	20	11	5	5
Equisetum arvense	20	11	4	5
Hypochaeris radicata	20	11	2	1

3.3.2 PCA Analysis

The PCA analysis proved to be problematic. PCA treats zeroes as similarities between relevés. The classic 'horseshoe' pattern emerged from using PCA on all of the relevés (see Figure 3.1). Removing the species that occurred in less than 10% of the relevés and then removing the species that occurred in less than 20% of the relevés made no difference (figure not shown). This continued to give the horseshoe shape. Removing species also potentially reduced the effectiveness of the Br-Bl approach as the species which were removed may be fidelity species. Thus PCA was dismissed as a method of analysis.

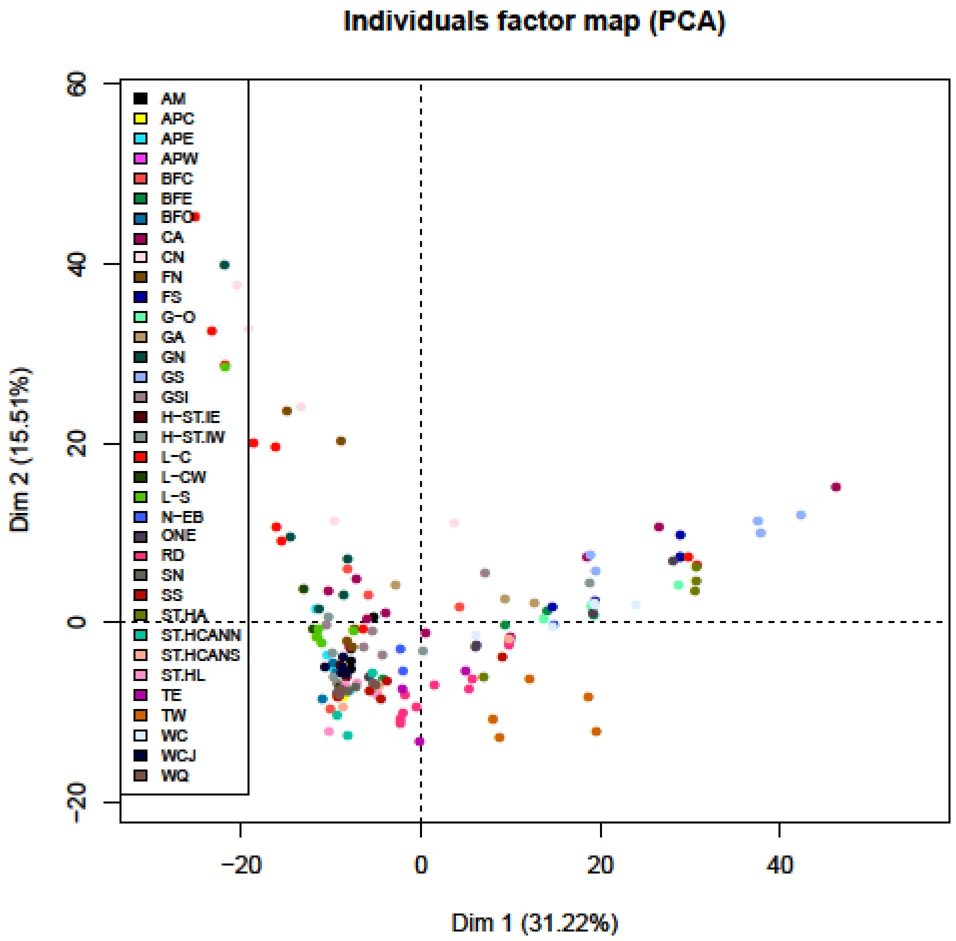


Figure 3.1 - PCA graph showing the 'horseshoe' pattern which emerged due to PCA treating zeroes as similarities between relevés and therefore PCA was dismissed as a method of analysis.

3.3.3 NMDS

NMDS is a multivariate approach that does not treat shared zeroes as evidence of similarity.

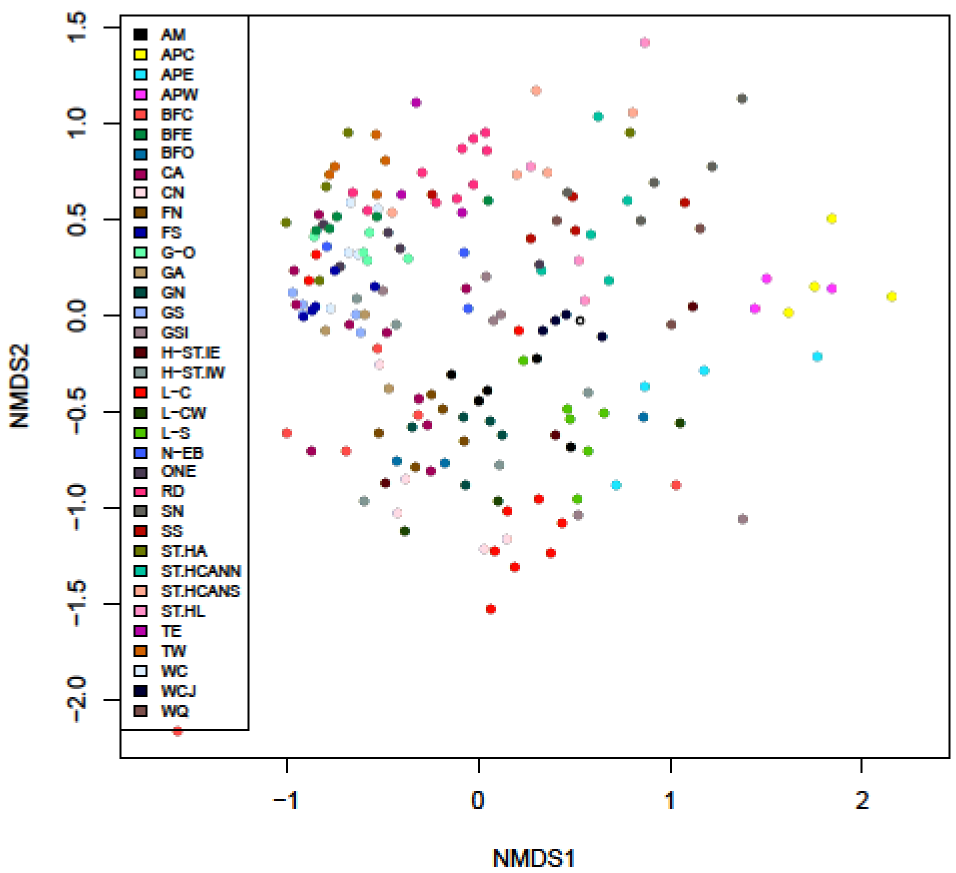


Figure 3.2 - NMDS graph results - the dots show the position of individual relevés, colour denotes relevé locations (see Table 3.1 for key to site codes). The graph shows no clear clustering pattern.

Figure 3.2 shows there to be no clear clustering of the relevés. Loose clustering occurs, particularly of relevés from the same site such as Runcorn Docks (RD - fuchsia) and Amlwch (AM - black). The graph also shows clustering of relevés that are not from the same site such as Blaenau Ffestiniog Embankment (BFE - dark green) and Gobowen – Oswestry (G-O - mint green).

3.3.4 Hierarchical Cluster Analysis

The results from the hierarchical cluster analysis show clear splits in the data (see Figure 3.3). At the highest level, there is a clear two-way split which is not equal in size.

Several species with an IndVal greater than or equal to 0.400 were found in each level of clustering. These species are presented with the main clusters in Figure 3.3. Figure 3.4 shows the entire hierarchical clustering of all relevés. Significant IndVals <0.400 do exist, see Table 3.3. However these were not used to characterise a cluster.

Table 3.3 IndVal data					
	IndVal	Fidelity	Exclusivity	Mean % cover in cluster	Mean % cover elsewhere
CLUSTER A					
Epilobium ciliatum	**0.9110**	**95%**	**95%**	**2**	**1**
Geranium robertianum	**0.7633**	**84%**	**46%**	**18**	**2**
Fraxinus excelsior	**0.4305**	**53%**	**38%**	**15**	**5**
Holcus lanatus	0.3807	79%	19%	12	4
Lotus corniculatus	0.2865	32%	86%	18	5
Rhododendron ponticum	0.2632	26%	100%	1	NA
Calluna vulgaris	0.2632	26%	100%	1	NA
Polytrichum commune	0.2105	21%	57%	15	NA
	0.2105	21%	100%	7	NA
Rhytidiadelphus squarrosus	0.1705	32%	38%	3	4
Viola riviniana	0.1701	21%	67%	1	1
Molinia caerulea	0.1579	16%	100%	37	NA
Hypericum tetrapterum	0.1579	16%	100%	1	NA
Geum rivale	0.1579	16%	100%	1	NA
Teucrium scorodonia	0.1427	21%	67%	2	4
Ulex gallii	0.1053	11%	100%	1	NA
Dicranum scoparium	0.1053	11%	100%	16	NA
CLUSTER B					
Eupatorium cannabinum	**0.8038**	**93%**	**72%**	**8**	**16**
Agrostis stolonifera	**0.6478**	**71%**	**40%**	**11**	**2**
Epilobium hirsutum	0.2986	36%	38%	5	2
Festuca ovina	0.2587	57%	50%	2	3
Buddleja davidii	0.1862	29%	27%	21	13
Salix cinerea	0.1786	21%	60%	2	3
Senecio squalidus	0.1429	14%	100%	1	NA
Euphrasia officinalis agg	0.1334	14%	67%	3	2
CLUSTER C					
Arrhenatherum elatius	**0.3589**	**100%**	**44%**	**25**	**10**
Rubus fruticosus agg	0.2884	83%	32%	10	8
Hypnum cupressiforme	0.2455	28%	65%	14	2
Bryoerythrophyllum recurvirostrum	0.1581	18%	70%	2	1
CLUSTER D					
Vulpia bromoides	**0.8461**	**100%**	**74%**	**23**	**4**
Galium aparine	**0.7873**	**100%**	**50%**	**1**	**1**
Anthriscus sylvestris	**0.6928**	**80%**	**50%**	**2**	**2**
Pimpinella saxifraga	**0.6000**	**60%**	**100%**	**2**	**NA**
Veronica arvensis	**0.5930**	**80%**	**67%**	**1**	**2**
Picris echioides	**0.5365**	**70%**	**59%**	**2**	**1**
Sonchus asper	**0.4344**	**80%**	**42%**	**2**	**2**
Linum catharticum	0.3750	50%	42%	1	2
Crepis vesicaria	0.3474	40%	80%	1	4
Hypochaeris radicata	0.2752	50%	35%	2	2
Centaurium erythraea	0.2496	30%	36%	1	1
Rumex crispus	0.2236	30%	43%	2	1
Cerastium fontanum	0.2131	40%	43%	1	1
Senecio jacobaea	0.2100	90%	22%	1	2
Conyza canadensis	0.1974	30%	33%	2	4
Senecio viscosus	0.1943	40%	33%	1	3
Blackstonia perfoliata	0.1000	10%	100%	1	NA

Table 3.3 Species significantly determined with each cluster determined by indicator value (IndVal, Dufrene & Legendre, 1987). IndVal is a product of exclusivity, the faithfulness to a cluster, and its fidelity, the extent to which it is found in that cluster. Also listed is the mean % cover both within the cluster with which it is significantly associated and the remaining relevés. Species used to characterise a cluster are shown in bold.

Table 3.3 IndVal data					
CLUSTER E					
Linaria vulgaris	**0.6711**	**100%**	**48%**	**3**	**2**
Deschampsia cespitosa	**0.6474**	**79%**	**55%**	**6**	**4**
Tanacetum vulgare	**0.6149**	**64%**	**82%**	**5**	**5**
Bryum argenteum	**0.4896**	**50%**	**88%**	**1**	**1**
Betula pendula	**0.4724**	**86%**	**63%**	**5**	**7**
Agrostis capillaris	**0.4316**	**86%**	**23%**	**2**	**2**
Plantago major	0.3715	64%	41%	1	2
Epilobium palustre	0.3353	57%	63%	1	1
Anisantha sterilis	0.3153	36%	56%	2	1
Epilobium parviflorum	0.2973	86%	31%	1	1
Cirsium arvense	0.2687	43%	33%	1	1
Echium vulgare	0.2143	21%	100%	5	NA
Ceratodon purpureus	0.2093	36%	28%	3	2
Chamerion angustifolium	0.2031	79%	21%	2	2
Reseda luteola	0.2015	21%	100%	7	NA
Verbascum thapsus	0.1565	21%	67%	7	3
Hypericum perforatum	0.1385	29%	54%	2	2
Lactuca serriola	0.1179	14%	67%	2	4
CLUSTER F					
Schistidium crassipilum	**0.7205**	**73%**	**75%**	**9**	**1**
Urtica dioica	**0.6609**	**91%**	**45%**	**1**	**1**
Cardamine flexuosa	**0.6364**	**64%**	**100%**	**6**	**NA**
Schistidium apocarpum	**0.6364**	**64%**	**100%**	**4**	**NA**
Barbula convoluta	**0.5200**	**55%**	**67%**	**3**	**2**
Epilobium montanum	**0.4330**	**100%**	**19%**	**2**	**1**
Cardamine hirsuta	0.3409	3%	75%	1	2
Sagina procumbens	0.3060	36%	27%	6	1
Alliaria petiolata	0.2727	27%	100%	1	NA
Myosotis arvensis	0.2283	27%	43%	2	2
Veronica beccabunga	0.1818	18%	100%	5	NA
Arabidopsis thaliana	0.1488	27%	75%	1	2
Myosotis discolor	0.1283	18%	29%	1	1
CLUSTER G					
Festuca rubra	**0.4147**	**67%**	**20%**	**14**	**4**
Poa annua	0.2316	29%	81%	2	1
Dactylis glomerata	0.2302	56%	24%	4	3
Plantago lanceolata	0.2301	38%	37%	3	1
Brachythecium rutabulum	0.2215	50%	51%	5	5
Achillea millefolium	0.1818	18%	58%	13	NA
Rumex acetosa	0.1697	21%	67%	2	1
Crataegus monogyna	0.1688	26%	64%	1	1
Trifolium dubium	0.1430	18%	86%	4	2
Hedera helix	0.1364	14%	44%	3	NA
Vicia sativa	0.1364	14%	78%	2	NA

Table 3.3 Continued. Species significantly determined with each cluster determined by indicator value (IndVal, Dufrene & Legendre, 1987). IndVal is a product of exclusivity, the faithfulness to a cluster, and its fidelity, the extent to which it is found in that cluster. Also listed is the mean % cover both within the cluster with which it is significantly associated and the remaining relevés. Species used to characterise a cluster are shown in bold.

The cluster analysis identified seven major clusters (A-G; Fig 3.3). Clusters A, B and C are in major cluster 1, characterised by *Arrhenatherum elatius* (IndVal = 0.75) and *Rubus fruticosus* agg. (0.45). Cluster B and C are in major sub-cluster 4, characterised by *Arrhenatherum elatius* (0.47). *Arrhenatherum elatius* (0.35) characterises cluster C with *Rubus fruticosus* agg. and two moss species. *Epilobium ciliatum* (0.91), *Geranium robertianum* (0.76) and *Fraxinus excelsior* (saplings) (0.43) characterise cluster A while *Eupatorium cannabinum* (0.80) and *Agrostis stolonifera* (0.65) characterise Cluster B.

There are 19 relevés in Cluster A, from the following railway sites: Blaenau Ffestiniog Open, Blaenau Ffestiniog Embankment, Blaenau Ffestiniog Cutting, Trecwn East and Trecwn West. Cluster B is comprised of 14 relevés from the following railway sites: St. Helens Link, St. Helens Acid Works, St. Helens Canal South and Fleetwood South. Cluster C is comprised of 40 relevés from the following railway sites: Blaenau Ffestiniog Embankment, Cambridge, Golborne South, Oswestry North Embankment, Woodthorpe Colliery, Staveley North, Fleetwood South, Golborne South, Newport - Ebbw Vale, St. Helens Acid Works, Golborne Ash, Leek - Cauldon Quarry Wooded and Leek - Cauldon Quarry.

Major cluster 2 is characterised by the three species (*Senecio jacobaea*, 0.47; *Festuca rubra*, 0.44 and *Taraxacum officinale* agg. 0.40). Major cluster 2 in turn is split into two major sub-clusters (5 and 6). Major Sub-cluster 5 is characterised by *Vulpia bromoides* (0.91) and *Linaria vulgaris* (0.44). It incorporates cluster D with seven indicator species (*V. bromoides*, 0.84;

Galium aparine, 0.79; *Anthriscus sylvestris*, 0.69; *Pimpinella saxifraga,* 0.60; *Veronica arvensis*; 0.59, *Picris echinoides*, 0.54 and *Sonchus asper*, 0.43), while cluster E is also typified by a large suite of species (*L. vulgaris*, 0.67; *Deschampsia cespitosa*, 0.64; *Tanacetum vulgare*, 0.61; *Bryum argenteum*, 0.49; *Betula pendula*, 0.47 and *Agrostis capillaris*, 0.43). Major sub-cluster 6 is characterised by *F. rubra* (0.4) and this is split into cluster F characterised by six species (*Schistidium crassipilum*, 0.72; *Urtica dioica*, 0.66; *Cardamine flexuosa*, 0.63; *Schistidium apocarpum*, 0.64; *Barbula convoluta*, 0.52 and *Epilobium montanum*, 0.433) while Cluster G is characterised by *F. rubra* only (0.4).

There are 10 relevés in Cluster D from Runcorn Docks only. 14 relevés form Cluster E from the following railway sites: Woodthorpe Colliery Junction, Staveley South and Staveley North. Cluster F is comprised of 11 relevés from the following railway sites: Appleby Embankment, Appleby Wet and Appleby Cutting. Cluster G is the largest cluster, comprised of 66 relevés. These are from the following railway lines: Golborne North, St. Helens Canal North, Fleetwood North, Leek - Cauldon Quarry Wooded, Blaenau Ffestiniog Cutting, Wirksworth Quarry, Oswestry North Embankment, Newport - Ebbw Vale, Gobowen - Oswestry, Histon - St. Ives West, Histon - St. Ives East, Leek - Stoke, Leek - Cauldon Quarry, Golborne South, Amlwch and Carrington.

Cluster G is the largest with 66 samples. Most clusters contain relevés from more than one location, the exception being Cluster D, in which all of the relevés are from Runcorn Docks. There is no relationship between number of relevés in a cluster and the number of significant indicator species.

The block diagram in Figure 3.5 gives a view of the indicator species distribution per cluster. This is a visualisation of the data used to generate the indicator values. While species are found in blocks which typify the cluster, if found in the majority of relevés of that cluster they are also likely to occur sporadically in other clusters.

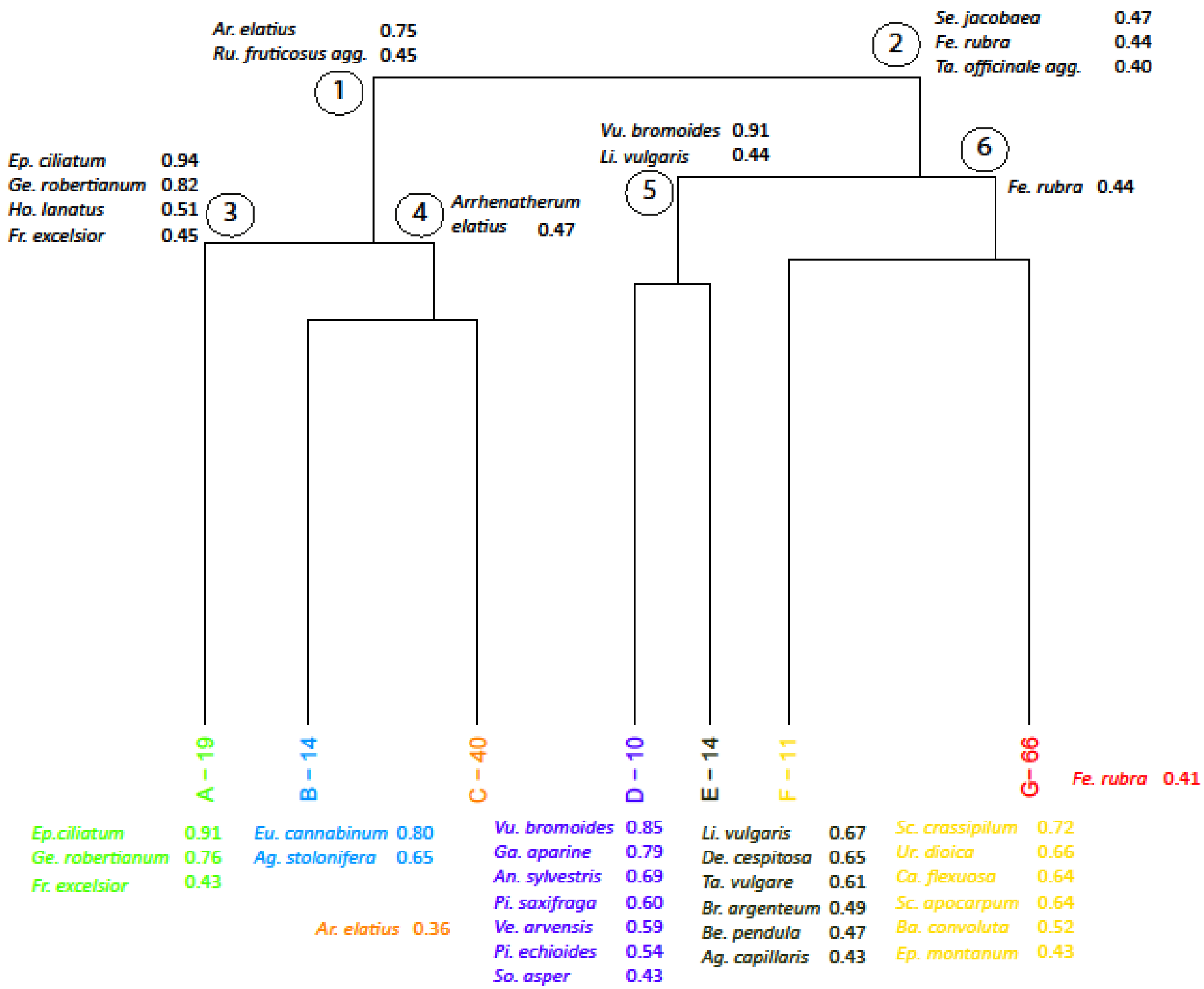


Figure 3.3 - Hierarchical Cluster Analysis of disused railway lines, showing six major splits. The numbers in circles denote major splits and the letters denote final clusters. The numbers denote the number of relevés within that cluster.

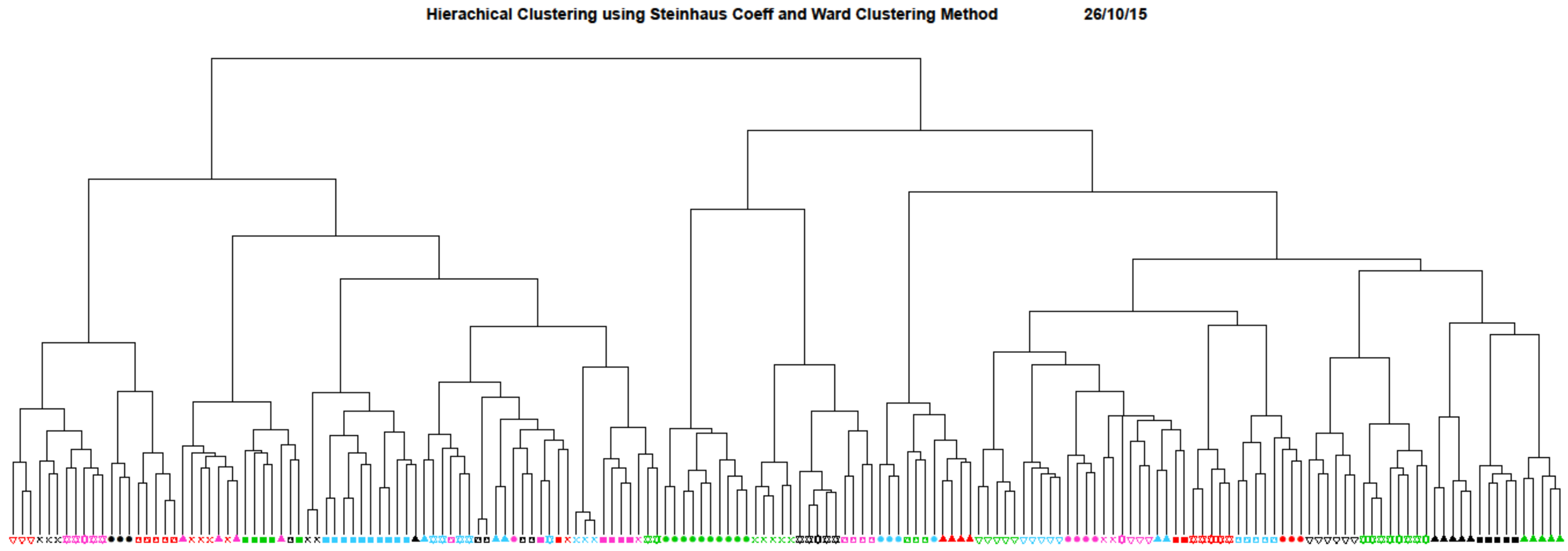
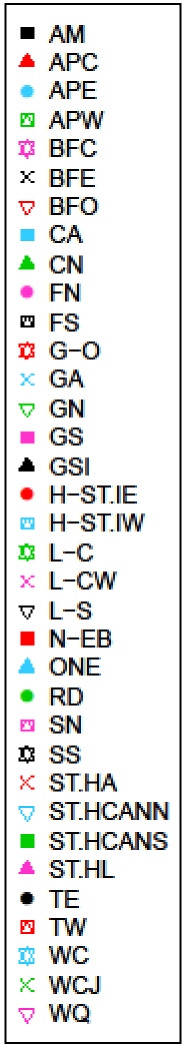


Figure 3.4 - Hierarchical Cluster Analysis of all relevés. Differently coloured symbols identify the different sites, as presented in the key below.


AM
APC
APE
APW
BFC
BFE
BFO
CA
CN
FN
FS
G–O
GA
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GS
GSI
H–ST.IE
H–ST.IW
L–C
L–CW
L–S
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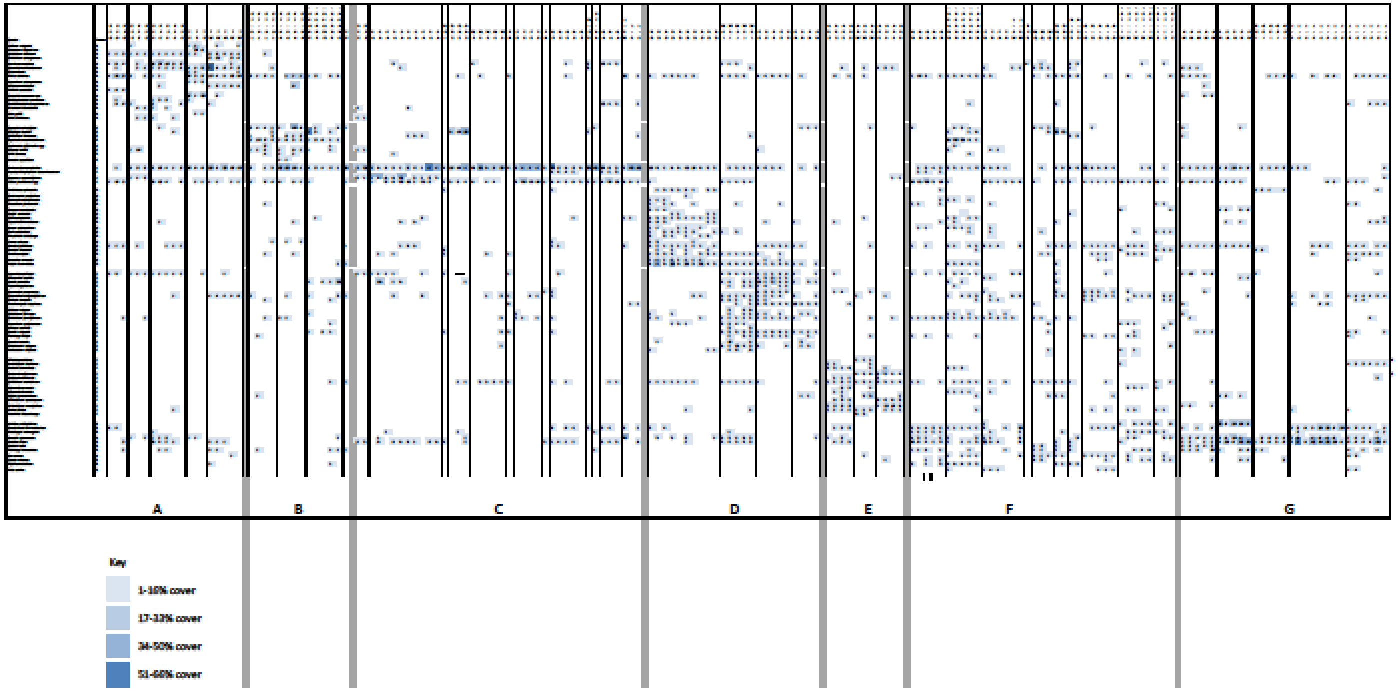

Table 3.4. Block diagram showing distribution of species across clusters. Species with significant Indicator Values are in the left hand column. Relevés are sorted by clusters which are delineated by the thick vertical lines. Blue colouring indicates presence of the species in that relevé, the darker the blue colour the higher the percentage cover.

3.4 DISCUSSION

A total of 246 species were recorded across all of the sites using the Br-Bl method. This is a slight decrease in the number recorded using the NVC method, described in Chapter 2, where 268 species were recorded in total across all of the sites. This difference is due to the slightly smaller area surveyed with some Br-Bl relevés. Different Br-Bl relevé sizes sometimes demand statistical treatment to make relevés comparable (e.g. Chytrý & Otýpková, 2003). However, the close similarity of relevé sizes across the survey render such processes unnecessary.

32 species are found in at least 20 relevés, although only three species are found in over 50% of relevés. Hence the vast majority of species (214) are found in only a few relevés. All species are found at very low coverage reflecting the open vegetation characteristic of early successional vegetation.

Multivariate analysis, although frequently used in vegetation studies, proved of little value in this study. Cluster analysis proved more useful, an approach some authors use exclusively (e.g. Angiolini *et al*, 2006), although some authors have found both multivariate analysis and hierarchical cluster analysis to be useful e.g. Greller *et al* (2000). PCA analysis resulted in the horseshoe shape and was subsequently dismissed. NMDS showed no clear clustering of the relevés. No pattern emerged from the data using NMDS whereas cluster analysis proved to be more revealing with clear splits in the composition of the relevés.

Seven communities are apparent from the hierarchical clustering. Clusters A, B and C are split from Clusters D, E, F and G by the presence of *Arrhenatherum elatius* in the former clusters*.* Within this split, lie further splits based on the presence of either *Fraxinus excelsior* or *Geranium robertianum*, i.e. a move ultimately towards scrub and shaded communities and the split towards damper communities with *Eupatorium cannabinum* and *Agrostis stolonifera.*

The community identified by Cluster A is dominated by *Epilobium ciliatum* and *Geranium robertianum* with abundant *Fraxinus excelsior* seedlings. This is then a mixture of grass species (*Holcus lanatus*, *Molinia caerulea*), which may be present with woody species (*Rhododendron ponticum*, *Calluna vulgaris* and *Ulex gallii*) and various forbs of low frequency (see Table 3.3).

The Cluster B community is distinct, featuring abundant *Eupatorium cannabinum* and *Agrostis stolonifera* with occasional woody components such as *Buddleja davidii* and *Salix cinerea*, along with a mixture of forbs (Table 3.3).

Arrhenatherum elatius is a feature of both communities described above, however, it is most strongly linked to Cluster C, which is a loose assemblage of mosses (*Hypnum cupressiforme* and *Bryoerythrophyllum.recurvirostrum*) and *Rubus fruticosus* agg.

Of the four communities in the other major cluster, Cluster D is by characterised by *Vulpia bromoides* occurring with *Galium aparine*, *Anthriscus sylvestris* and *Picris echioides.*

The fifth community features a combination of forbs (*Linaria vulgaris*, *Tanacetum vulgaris*) with grass species (*Deschampsia cespitosa*, *Agrostis capillaris*). Woody species are represented by *Betula pendula*. Other species typifying this community are medium-sized forbs (e.g. *Epilobium parviflorum*, *Cirsium arvense* and *Chamerion angustifolium*).

The sixth cluster is dominated by *Urtica dioica* with many moss species (e.g. *Schistidium crassipilum* and *Schistidium apocarpum*) and small forbs (e.g. *Cardamine hirsuta*, *Sagina procumbens* and *Myosotis arvensis*).

The final community is another loose aggregation of species characterised by *Festuca rubra* with a mixture of grass species (*Dactylis glomerata* and *Poa annua*) and medium-sized forbs (e.g. *Achillea millefolium* and *Plantago lanceolata*).

There are no absolute fidelity species (Figure 3.4, Table 3.3, Table 3.4). However this pattern is typical in ruderal communities, therefore separation is determined by a stronger association of species than elsewhere in the sites surveyed. No comparative studies have been found of ruderal communities, which use Indicator Values to determine community composition.

Plant communities with similar constant species to the NVC communities (described in Chapter 2) emerged from the Br-Bl data. Major cluster 1, which is dominated by *Arrhenatherum elatius*, is commensurate with the findings of the NVC results, which shows a cluster of sites which support the basics of an MG1 grassland but with a ruderal component and a lack of umbellifers. Cluster A includes a strong ruderal component (e.g. *Epilobium ciliatum*) with heathland species, another affinity with the NVC results. Another set of sites within the NVC support MG1 grassland with woody elements. This can be aligned to Cluster B, featuring *Buddleja davidii* and *Salix cinerea* as components. The four communities in the other major cluster are dominated by ruderal species. Few affinities were found within the NVC data to Open Vegetation (OV) communities. The grass-dominated OV23 was loosely aligned to a few sites. Cluster G has *Festuca rubra* as an indicator species.

Hierarchical clustering may be more sensitive to the differences in the community composition as a result of the finer scale of analysis, 1-100 per species per relevé, compared to NVC analysis which uses a five point Domin score per species per site. In addition, differences between the results of the Br-Bl approach and the results of the NVC approach may be due to differences in the approach to analysis.

It is difficult to compare the results of the Br-Bl hierarchical clustering in this study with continental studies. Although authors on the continent have used hierarchical clustering to describe and name plant communities from ruderal sites (e.g. Lososová *et al*, 2006; Simonová, 2008 and Lasić *et al*, 2014), none of the species or plant assemblages published resemble those found during this study. Moreover, previously described continental ruderal plant associations do not resemble those found here. This raises the possibility that these communities are unique to the UK, a product of the habitat combined with the oceanic climate.

The lack of published work in this field and hence the lack of knowledge of the potential architects of community composition means that there is a need to investigate the factors. Chapter 4 will investigate the environmental variables on each of the sites and explore possible environmental reasons for the community composition.

CHAPTER 4 – FACTORS INFLUENCING COMMUNITY COMPOSITION

4.1 INTRODUCTION

The successional process and the drivers behind it have long been debated. Many early ecologists believed in the climax community, i.e. that there were distinct stages from pioneer colonisation to a stable community, determined by the ability of the initial successful colonists to tolerate extreme conditions through to the competitive abilities of the species present within the climax community (Clements, 1936). This approach is described in the classic sand dune succession studies (Ranwell, 1960 and Pye, Saye & Blott, 2007). Other ecologists have argued that succession was a random and unpredictable event, with individual species exhibiting variation in their response to environmental factors such as disturbance and stress (e.g. Gleason, 1917). Studies have been carried out on the factors influencing community composition at various successional stages. While the view of a deterministic view of succession based on intrinsic plant characteristics, primarily life strategies (e.g. competitiveness) is still widely held (Grime, 2001), this is far from a universal viewpoint. Individual adaptations to disturbance and stress are considered more important by some authors (e.g. Caccianiga *et al*, 2006) while the role of stochastic processes is borne out in large scale succession studies such as tree species distribution in Europe since the Ice Age (Svenning & Skov, 2007). This debate is still current, leading to early successional processes being the subject of much research, although the recognised contribution of stochastic factors has led it more recently to frequently be termed vegetation dynamics (Pickett et al, 2008).

More recently, a 'reductionist' approach has been developed, to try and predict the successional process. This has meant ecologists studying vegetation processes at a local scale, rather than a global or regional scale. The view is that ecosystems are in a constant state of change and the various components respond individualistically. Therefore, succession is not recognised as a procession of competitive species but as a random assemblage of species being constantly replaced in a mosaic of patch communities (Walker & del Moral, 2003). Therefore, predicting succession is difficult and that in any given locality, there can be multiple pathways that the successional stages can take. This was the conclusion on the dune systems in the Netherlands (van der Maarel *et al*, 1985) and on deglaciated land in Alaska (Chapin *et al*, 1994). Hence phytosociologists currently struggle with predicting succession because of the ecological complexities at the community level and the individual plant species level (Walker, 2012).

Nevertheless, modern ecologists have also sought to identify successional processes based upon abiotic and biotic variables. For instance climate has long been known as a factor influencing community composition (e.g. Peinado *et al*, 2005a & 2005b, & Lososová *et al*, 2006). Climate change has refocused studies into climate affecting plant communities, especially those close to human settlements (e.g. Turner *et al*, 2004). Hence environmental factors such as rainfall, aspect, altitude, mean temperatures are typically incorporated into vegetation dynamic studies. For instance Hodge & Harmer (1996) studied rainfall, the soil characteristics and the depth of vegetation penetration when investigating woody colonisation, while local moisture levels have been shown to vegetation establishment (Prach *et al*, 2013). Seed rain has been demonstrated to be a major influence in the direction of succession (Evans & Dahl, 1955; Lanta & Leps, 2009).

Time is also an important factor in succession (e.g. Chapin *et al*, 1994). Rates of species turnover are known to decline with time since abandonment or disturbance (Walker & del Moral, 2003). This is due to a number of factors including increase in shading from long-term plant species, lack of open ground making establishment difficult for pioneer species and increase in nutrients within the humic layer allowing for a healthier plant growth and longer term survival.

In synanthropic habitats the nature of the substrate is an important limiting factor, given that ex-industrial sites tend to have soils of poor structure and which are often heavily contaminated. This includes poor water retention and poor nutrient levels (Hiller, 2000) and heavy metal content (Malawska & Wilkomirski, 2000). For example, lead was found to be the most limiting factor for plant diversity during a study of old lead mines in the Pennines (Clark & Clark, 1981). The pH of the substrate can also be an important variable (e.g. Hall, 1959). McLaughlin & Crowder (1988) studied the environmental factors affecting the distribution of two grass species; *Agrostis gigantea* and *Poa pratensis*, on copper-nickel mine tailings in Ontario, Canada. Despite the substrate being contaminated with iron, nickel and copper, pH and moisture significantly affected distribution of grass species.

Nearly all studies of plant establishment on ex-industrial land have investigated the nutrient load in the substrate. Nitrogen, Potassium, Calcium, Magnesium and Phosphorus are commonly measured. The nutrient load helps to understand the ability for plants to not only colonise but to persist within the site. For example, a study of china clay waste in Cornwall (Roberts *et al*, 1981), found that the Potassium, Calcium and Magnesium content of the waste was lower than the control site but that the Phosphorus levels were relatively high, a product of the ease with which these elements are leached out of the china clay waste whereas Phosphorus is more immobile in soil, therefore resistant to leaching.

In previous chapters, the suitability of disused railway lines as study sites for phytosociological work has been discussed. They are a finite habitat, built to a similar specification throughout the UK with a well-drained granite ballast. Thus the starting point of all disused sites is very similar. Railway ballast is typically composed of hard, angular granite chippings, the main purposes of which are to distribute stress and allow drainage. Historically (pre-1970's) a variety of mediums have been used, mainly ash, until steam locomotives ceased to be used, but also broken bricks and clay (Claisse & Calla, 2006). Since the nationalisation of the railways, the British standard has been granite of 50-32mm in size (Granite R/Track Spec EN13450) (NR/L2/TRK/1800) (National Rail). Therefore the substrate is fixed and not a variable influence on plant succession. Moreover, plant establishment is prevented while the ballast is in use due to annual herbicide treatment. Hence the development of vegetation following closure presents a natural experiment where the effects of time and environment and then soil development can be studied (Suominen, 1979).

This chapter investigates the potential role of environmental, edaphic and temporal factors on community development and thus to ascertain the predictability of ruderal community composition. These factors are considered across all the relevés and at the level of the seven communities identified in the previous chapter.

The following factors were utilised to investigate whether there is a pattern to ruderal plant community composition: time since abandonment, aspect, slope, altitude, mean rainfall, mean temperature, pH, soil moisture content, soil organic content, and the following metals: Magnesium, Lead, Cadmium, Potassium, Calcium, Copper and Nickel. The role of Nitrogen and soil fertility are examined through the use of Ellenberg indicator values.

4.2 METHODS

4.2.1 Site selection and soil sampling

The reasoning behind the selection of each disused railway line has been discussed in details in Chapters 2 and 3.

A total of 176 relevés were studied from a total of 35 sites from 22 different railway lines. At each relevé location, a soil sample was taken. This involved digging below the ballast to reach the recently developed humic layer to obtain enough material. The material gathered at each relevé tended to be approximately 100g, although at some relevés, it proved impossible to extract enough soil to undertake analysis. Table 4.1 gives the number of soil samples taken per site. At the following sites, it was not possible to extract soil: Amlwch, Histon - St. Ives East, Leek - Cauldon Quarry, Leek - Cauldon Wooded, Newport - Ebbw Vale, Oswestry North Embankment and St. Helens Link.

Table 4.1 No. of soil samples per site	
SITE	**NO OF SOIL SAMPLES**
Appleby Cutting	4
Appleby Embankment	4
Appleby Wet	3
Blaenau Ffestiniog Cutting	6
Blaenau Ffestiniog Embankment	5
Blaenau Ffestiniog Open	3
Cambridge	5
Carrington	8
Fleetwood North	5
Fleetwood South	5
Gobowen – Oswestry	5
Golborne Ash	3
Golborne North	5
Golborne Sidings	6
Golborne South	5
Histon – St. Ives West	5
Leek – Stoke	5
Runcorn Docks	10
St. Helens Acid Works	5
St. Helens Canal North	2
St. Helens Canal South	5
Staveley North	5
Staveley South	5
Trecwn East	3
Trecwn West	5
Wirksworth Quarry	3
Woodthorpe Colliery	5
Woodthorpe Colliery Junction	5
TOTAL NO. OF SOIL SAMPLES	135

Samples were placed in sealed plastic bags until they were returned to the laboratory (within 24 hours of gathering), where they were then air dried to reach a constant weight. The following tests were then undertaken:

pH

The pH of the soil samples was measured using a pH meter after first dissolving the soil in solution. This was achieved by mixing the soil with 1M potassium chloride (KCl) solution in a solid liquid ratio of 1:2.5, by adding 12.5ml of KCl solution to 5g of soil exactly weighed. The soil KCl solution was mixed on a magnetic stirrer for 2 minutes and then allowed to settle for 15 minutes. The glass electrode pH meter was then placed in the solution until a steady reading was given (a reading was considered steady when there is no more than 0.2pH units movement in 5 seconds).

Soil moisture content

The soil moisture content was determined by the gravimetric method; that is, from the weight of soil before and after drying in an oven at 80-85°C.

Soil organic content

The organic content of soil was determined by burning the soil in a muffle furnace, this converts any organic material to carbon dioxide (CO_2) and water (H_2O), leaving behind only the mineral content of the soil. The samples were placed in the furnace at 450°C for a minimum of eight hours. The samples were allowed to cool and reweighed for a final time. The organic content as a percentage was then calculated as a proportion of the dry weight.

Metal content

The metal content in the soils was analysed using an Atomic Absorption Spectrometer (AAS). This process uses a lamp that emits an element-specific frequency which excites a ground state atom of the chosen metal. As the exited atom returns to its ground state it releases energy in light form which can be measured giving a concentration of metal within a sample. To use this method the soils must first be digested in concentrated acid to release the metals from the organic material.

1g of soil was exactly weighed into a wide neck conical flask. 10ml of concentrated nitric acid was then added to the soil and heated on a hot plate for 1-2 hours until approximately 5ml of the solution remains, at this point another 10ml of concentrated nitric acid was added to the solution and heated again until 5ml remain. The soil solution was allowed to cool to room temperature and filtered through a micro glass fibre filter paper. The conical flasks containing the remnants of the soil acid solution were rinsed with distilled water which was then also passed through the filter paper and used to top up the filtered solution up to 25ml in a volumetric flask. To improve the accuracy of the flame absorption reading the prepared samples were diluted to a factor of 10^{-2} (1ml of soil solution made up to 100ml with distilled water).

For each metal a different element specific hollow cathode lamp (HCL) was required and the AAS was calibrated, this was done by using a “standard” of known milligrams per litre (mg/l), the AAS measured the absorbance rate of the standard and uses 3 standards to form a calibration curve which can then be used to calculate a concentration in ppm from the absorbance.

Following the calibration the soil solutions were run through the AAS. The soil solution was drawn into the flame 3 times for 5 seconds each, the AAS then calculated a time average reading. To account for the 10^{-2} dilution of the sample the result is multiplied by 100 to give the mg/l of the metal content in soil.

The metals tested were: Magnesium, Lead, Cadmium, Potassium, Calcium, Copper and Nickel. This group is similar to those undertaken in other studies (e.g. Malawska & Wilkomirski, 2000).

Nitrate and Phosphate

Nitrate assay was undertaken using the Merck Millipore equipment. This is a reflectometric determination carried out after reduction to nitrate and reaction with Griess reagent. However, the soil produced a colour that rendered the reading impossible and this approach was abandoned. Phosphate assay was carried out also using the Merch Millipore method. This was the phosphomolybdenum blue method.

Due to the small amount of soil collected on some sites and the difficulty of testing for both nitrate and phosphate, Ellenberg indicator values of N and F for each species were used as proxy. Almost all of the vascular species have Ellenberg Indicator Values (Ellenberg, 1988). For each relevé, the mean (weighted and unweighted) indicator score was calculated.

4.2.2 Data gathering and analysis

A number of environmental variables have been chosen to be analysed and compared as part of this study.

Time since abandonment

Time since abandonment was gathered from carrying out internet searches. There are many enthusiast websites regarding local disused lines. The time was taken from the last train ever to pass over the rails, not just when passenger services were cut. Typically, freight would continue to use the line for a few years after closure of passenger services before it was finally abandoned. The year of abandonment was taken to indicate the year that the final herbicide application was administered.

Aspect and altitude

Aspect was gathered from using a compass on the site. Given that the railway lines point in two directions, the aspect was restricted from 0° to 179°. This also allowed the value to be treated as a linear value. For lines on a curve, the aspect was determined by considering a tangent to the curve at the centre of the relevé. Altitude was determined from O.S. map contour lines.

Rainfall and temperature

Mean annual rainfall for each site was gathered from the historical almanac from the Weather Underground website www.wunderground.com. Mean annual rainfall is commonly used within other environmental studies (e.g. Cimalová & Lososová, 2009 and Simonová, 2008). Mean summer temperature (the growing season) was also gathered from the Weather Underground website. Mean summer temperature is also used in various studies (e.g. Duckworth *et al*, 2000 and Tikssa *et al*, 2009).

Statistical analysis

Statistical tests were undertaken using the package R (CRAN - Comprehensive R Archive Network). The strength of simple linear relationships between time since abandonment and Ellenberg N, Ellenberg F, species richness and species diversity was investigated.

Differences between the seven clusters in mean time since abandonment and Ellenberg N and F values were examined using ANOVA and post-hoc Tukey tests where appropriate.

Multivariate analysis was undertaken using Canonical Correspondence Analysis (CCA) to investigate the impact of climate, temporal and soil factors on the separation of the seven clusters identified in the previous chapter. To incorporate environmental variables into CCA, the values were standardised using the "range" standardisation in the decostand function of the vegan package in R. This scales all the measurements of each column to be between 0 and 1. With 1 being the highest value and 0 being the smallest.

ANOVA was used to test the significance of the CCA plot.

4.3 RESULTS

135 samples were used in the analysis. Soil could not be collected from all relevés.

Time since abandonment

Table 4.2 shows the years since abandonment of all sites surveyed.

Table 4.2 Years since abandonment per railway line				
Site	**Grid Reference**	**Time between abandonment and survey (years)**	**Year of closure**	**Reference**
Amlwch	SH 424913	16	1993	http://www.networkrailmediacentre.co.uk/content/Detail.aspx?ReleaseID=5698&NewsAreaID=2
Appleby Cutting	NY 694200	20	1989	http://www.disused-stations.org.uk/a/appleby_east/index.shtml
Appleby Embankment	NY 696195	20	1989	http://www.disused-stations.org.uk/a/appleby_east/index.shtml
Appleby Wet	NY 694199	20	1989	http://www.disused-stations.org.uk/a/appleby_east/index.shtml
Blaenau Ffestiniog Cutting	SH 705441	11	1998	http://www.penmorfa.com/Conwy/seven.htm
Blaenau Ffestiniog Embankment	SH 707439	11	1998	http://www.penmorfa.com/Conwy/seven.htm
Blaenau Ffestiniog Open	SH 704443	11	1998	http://www.penmorfa.com/Conwy/seven.htm
Cambridge	TL 428639	12	1992	http://www.disused-stations.org.uk/s/st.ives
Carrington	SJ 753903	14	1993	http://www.rmweb.co.uk/community/index.php?/topic/56808-the-clc-through-stockport
Fleetwood North and Fleetwood South	SD 328457	10	1999	www.wyre.gov.uk/download/downloads/id/1039/the_future_of_the_unused_poulton_to_fleetwood_railway_line-_stage_one_final_report
Gobowen – Oswestry	SJ300313	21	1988	www.cambrianrailways.com/html/history.htm
Golborne Lines	SJ 601993	5	2004	http://www.rmweb.co.uk/community/index.php?/topic/24837-oil-and-scrap-metals-traffic-haydock-merseyside/
Histon – St. Ives East	TL 397681	15	1992	http://www.disused-stations.org.uk/s/st.ives/
Histon – St. Ives West	TL 363694	15	1992	http://www.disused-stations.org.uk/s/st.ives/
Leek – Cauldon Quarry	SK 022538	17	1988	http://www.churnet-valley-railway.co.uk/cvr-history

Table 4.2 Years since abandonment per railway line				
Leek – Cauldon Quarry Wooded	SJ 996545	17	1988	http://www.churnet-valley-railway.co.uk/cvr-history
Leek – Stoke	SJ 939538	17	1988	http://www.geograph.org.uk/gallery/dismantled_disused_and_derelict_railways_6461
Newport – Ebbw Vale	ST 210965	4	2003	http://www.chartist.demon.co.uk/rdsw/ebbw.htm
Oswestry North Embankment	SJ 297302	21	1988	http://www.cambrianrailways.com/html/history.html
Runcorn Docks	SJ 499823	10	2009	http://www.8dassociation.btck.co.uk/TheStHelensRuncornGapRailway
St. Helens Acid Works	SJ 527938	2	2002	http://www.railforums.co.uk/showthread.php?t=88384&page=2
St. Helens Canal North	SJ 515950	2	2002	http://www.railforums.co.uk/showthread.php?t=88384&page=2
St. Helens Canal South	SJ 517949	2	2002	http://www.railforums.co.uk/showthread.php?t=88384&page=2
St. Helens Link	SJ 527939	2	2002	http://www.railforums.co.uk/showthread.php?t=88384&page=2
Staveley North	SK 440741	3	2006	http://signalboxes.com/seymour-jn.php
Staveley South	SK 442739	3	2006	http://signalboxes.com/seymour-jn.php
Trecwn East	SM 963324	18	1992	http://www.cukwiki.com/wiki/RNAD_Trecwn
Trecwn West	SM 956320	18	1992	http://www.cukwiki.com/wiki/RNAD_Trecwn
Wirksworth Quarry	SK 288546	15	1989	http://www.e-v-r.com/linehistory/
Woodthorpe Colliery	SK 459744	3	2006	http://signalboxes.com/seymour-jn.php
Woodthorpe Colliery Junction	SK 456742	3	2006	http://signalboxes.com/seymour-jn.php

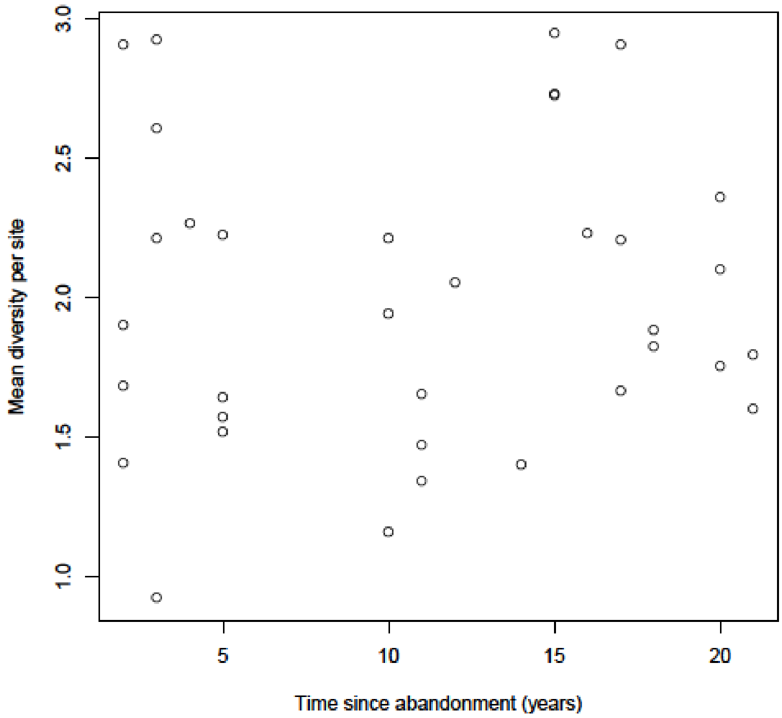

Figure 4.1. Scatterplot of mean of time since abandonment vs. mean species diversity per relevé per site, showing no relationship between time since abandonment and species diversity

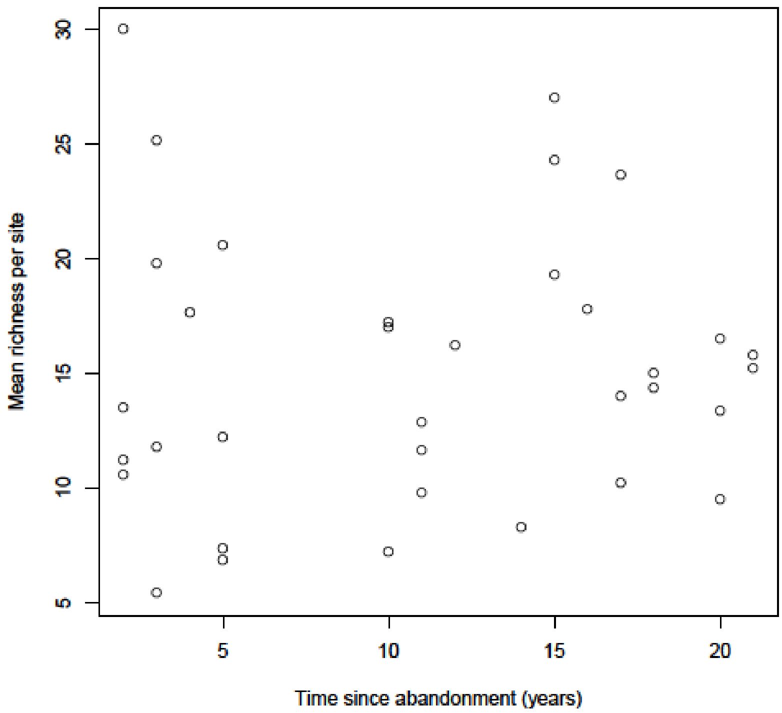

Figure 4.2. Scatterplot of mean of time since abandonment vs. mean species richness per relevé per site, showing no relationship between the two variables

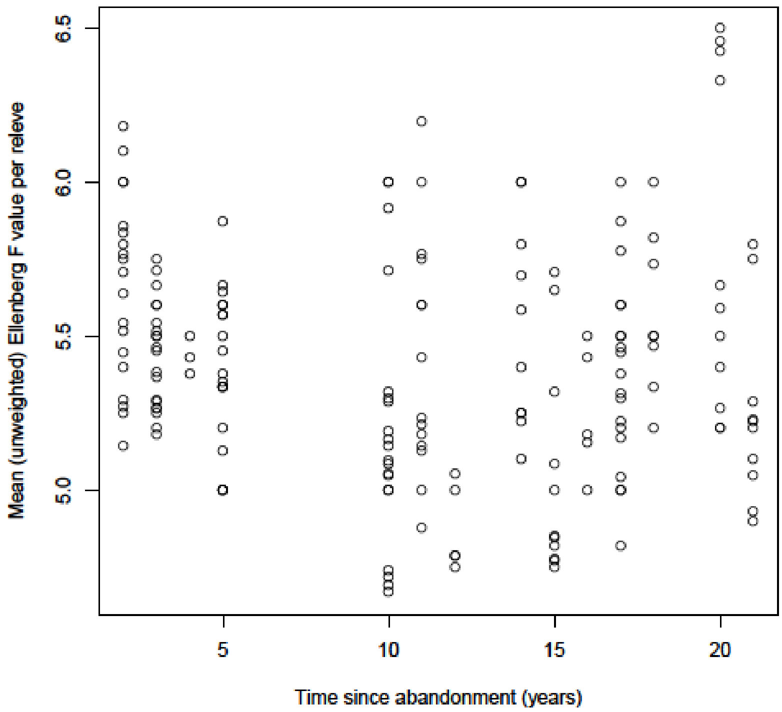

Figure 4.3. Scatterplot of mean of time since abandonment vs. mean Ellenberg F values per relevé per site, showing no relationship between time since abandonment and Ellenberg F values

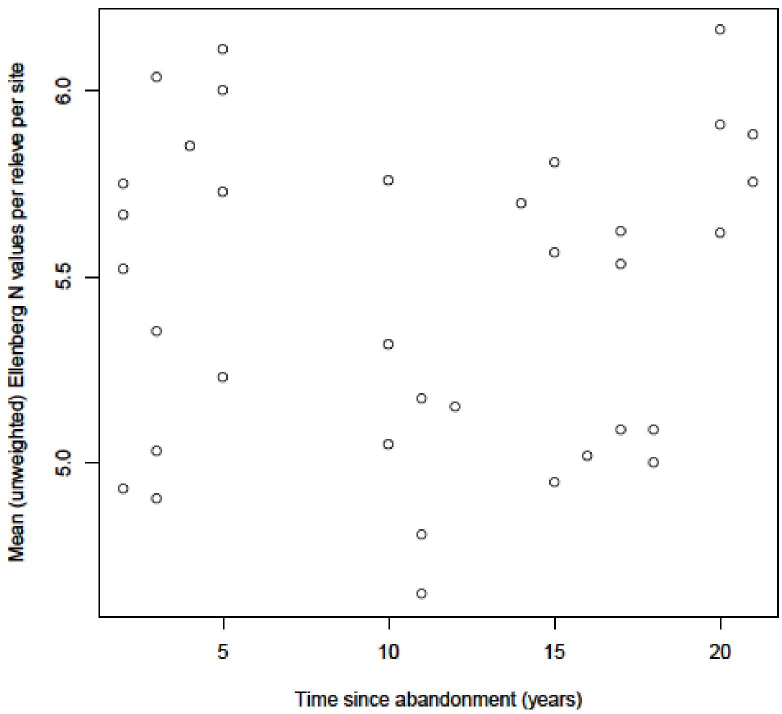

Figure 4.4. Scatterplot of mean of time since abandonment vs. mean Ellenberg N values per relevé per site, showing no relationship between time since abandonment and Ellenberg N values

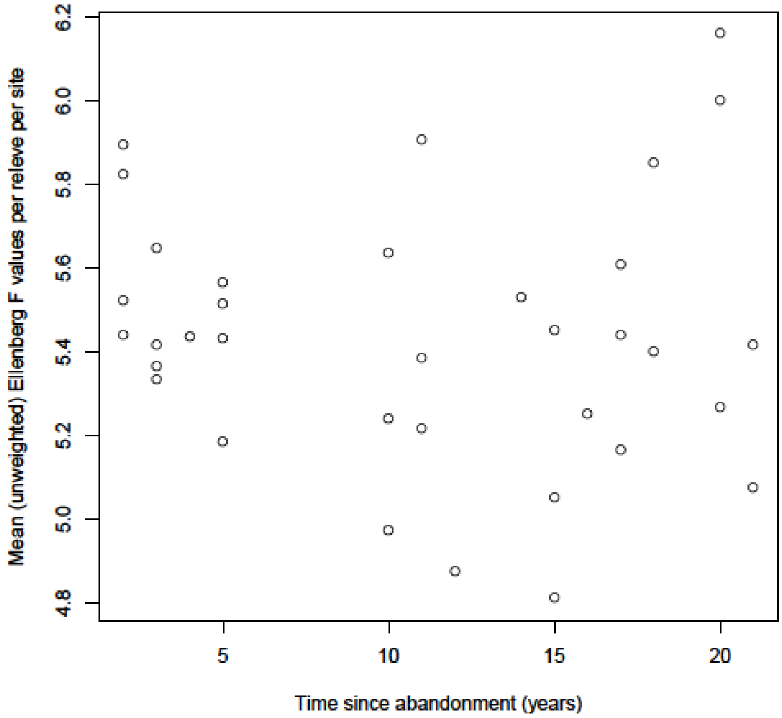

Figure 4.5. Scatterplot of mean of sites vs. mean Ellenberg F values per relevé per site, showing no relationship between the sites and mean Ellenberg F values

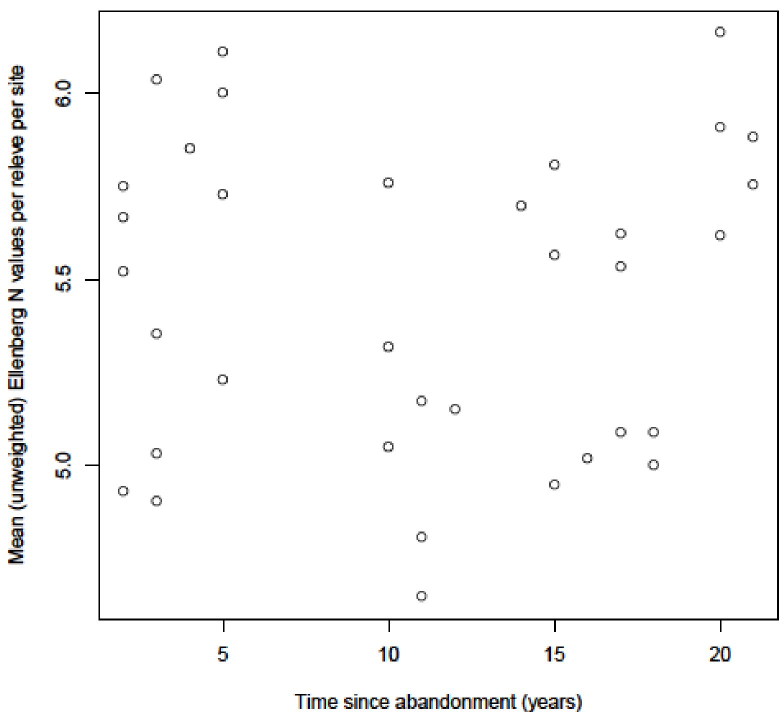

Figure 4.6. Scatterplot of mean of sites vs. mean Ellenberg N values per relevé per site, showing no relationship between the sites and Ellenberg N values

The lines surveyed show a range of time since abandonment ranging from the recently closed (e.g. St. Helens Acid Works; 2 years) to those abandoned for two decades (e.g. the Appleby sites). There is a good range of coverage between these two extremes. There is no relationship between time since abandonment and any of Ellenberg N, Ellenberg F, species richness and species diversity values (Figures 4.1 - 4.6). This outcome does not change, when data is considered per relevé or a mean value calculated across a site. The data presented here uses the unweighted values. Using unweighted or weighted Ellenberg means yields extremely similar results.

CCA and Hierarchical Clustering

Table 4.3 shows mean and standard deviations of time since abandonment, abiotic and edaphic factors. Superscripts of different letters identify significantly different mean values between clusters for the same measure. Absence of letters within a row of means indicates no significant differences.

Table 4.3. Mean and standard deviations							
Cluster	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Indicator species	*Ep. ciliatum*	*Eu. cannabinum*	*Ar. elatius*	*Vu. bromoides*	*Li. vulgaris*	*Sc. crassipilum*	*Fe. rubra*
	Ge. robertianum	*Ag. stolonifera*		*Ga. aparine*	*De. cespitosa*	*Ur. dioica*	
Altitude (m)							
Mean	170^{a}	30^{b}	70^{bc}	20^{b}	60^{bc}	160^{a}	90^{c}
Standard Deviation	70	10	70	0	0	0	80
Aspect (degrees)							
Mean	100^{ab}	90^{ab}	95^{ab}	45^{a}	85^{ab}	140^{b}	105^{b}
Standard Deviation	40	55	50	0	40	50	50
Years since line closure							
Mean	14^{ab}	3^{c}	10^{bc}	10^{abc}	3^{c}	20^{a}	14^{ab}
Standard Deviation	4	2	6	0	0	0	12
Mean Rainfall (mm)							
Mean	75^{ab}	48^{c}	68^{b}	76^{ab}	69^{b}	80^{a}	61^{d}
Standard Deviation	2	6	7	0	1	0	12
Mean Summer Temp (°C)							
Mean	15^{a}	16^{bcd}	16^{bc}	16^{d}	15^{ac}	14^{e}	16^{bd}
Standard Deviation	0	0	1	0	1	0	1
pH							
Mean	5.7^{a}	5.5^{a}	5.7^{a}	5.8^{a}	6.2^{b}	5.8^{a}	5.8^{a}
Standard Deviation	0.6	0.4	0.2	0.3	0.4	0.3	0.2
Moisture Content (%)							
Mean	0.87^{a}	1.8^{a}	0.92^{a}	3.64^{a}	3.92^{a}	2.23^{a}	2.64^{a}
Standard Deviation	1.22	2.66	1.02	0.33	7.53	0.92	3.77
Organic Content (%)							
Mean	18.57^{ab}	13.22^{ab}	18.41^{ab}	14.22^{ab}	52.04^{c}	24.13^{b}	11.97^{a}
Standard Deviation	5.75	8.06	9.85	3.61	12.89	8.71	8.36
Mg (mg/l)							
Mean	79.29	74.63	71.42	77.89	50.86	103.96	59.66
Standard Deviation	78.06	65.28	60.96	41.55	19.91	55.22	58.12
Pb (mg/l)							
Mean	16.06	84.62	18.09	7.12	6.10	29.97	37.81
Standard Deviation	8.72	86.32	15.50	2.10	4.68	12.01	93.91
K (mg/l)							
Mean	19.13	24.99	28.26	15.23	22.47	14.92	21.37
Standard Deviation	9.05	11.32	17.46	4.87	9.01	3.42	8.16
Ca (mg/l)							
Mean	56.12^{a}	842.47^{b}	92.61^{a}	112.87^{a}	129.19^{a}	194.76^{a}	213.7^{a}
Standard Deviation	59.38	1416.69	111.99	47.16	101.34	81.67	271.84
Cu (mg/l)							
Mean	5.57	17.95	8.50	13.93	12.93	6.06	20.23
Standard Deviation	1.26	8.99	7.81	3.77	20.22	1.25	24.70
Cd (mg/l)							
Mean	2.23	1.39	1.35	1.22	6.08	0.45	1.73
Standard Deviation	3.43	0.89	3.51	1.41	21.08	0.17	1.77
Ni (mg/l)							
Mean	18.23	14.55	18.95	15.29	17.64	16.62	12.78
Standard Deviation	4.05	11.16	8.57	2.04	2.73	4.15	5.89

ANOVA, used on the various factors examined, reveals some significant differences between clusters (Table 4.3). For instance, altitude varies from a mean per cluster of 20m asl to 170m asl with the significantly different altitudes between clusters; *Vulpia bromoides & Galium aparine* and *Eupatorium cannabinum* & *Agrostis stolonifera* at significantly lower altitudes with *Epilobium ciliatum & Geranium robertianum* and *Schistidium crassipilum* & *Urtica dioica* at significantly higher altitude with other clusters at intermediate altitudes. Aspect shows two significantly different extremes. *Vulpia bromoides* and *Galium aparine* at 45° and *Schistidium crassipilum & Urtica dioica* at 140° with the other clusters at intermediate angles. Year since closure shows two clusters with significantly different early closure dates (*Eupatorium cannabinum* & *Agrostis stolonifera* and *Linaria vulgaris* & *Deschampsia cespitosa*) while the *Schistidium crassipilum* and *Urtica dioica* cluster is significantly oldest. For pH the *Linaria vulgaris* and *Deschampsia cespitosa* cluster has a significantly higher pH than all other clusters. For some of the factors (altitude, aspect, time since abandonment, mean rainfall and mean summer temperatures) show no variation, while other samples show large variance. There is no easily discernible pattern to the significant differences.

There are no significant differences between the clusters for the majority of soil characters (moisture content, Mg, Pb, K, Cu, Cd and Ni). Organic content has significant differences between clusters and Calcium content is significantly higher in cluster B (*Eupatorium cannabinum* and *Agrostis stolonifera* community) than all others. All other edaphic factors show no significant differences between clusters.

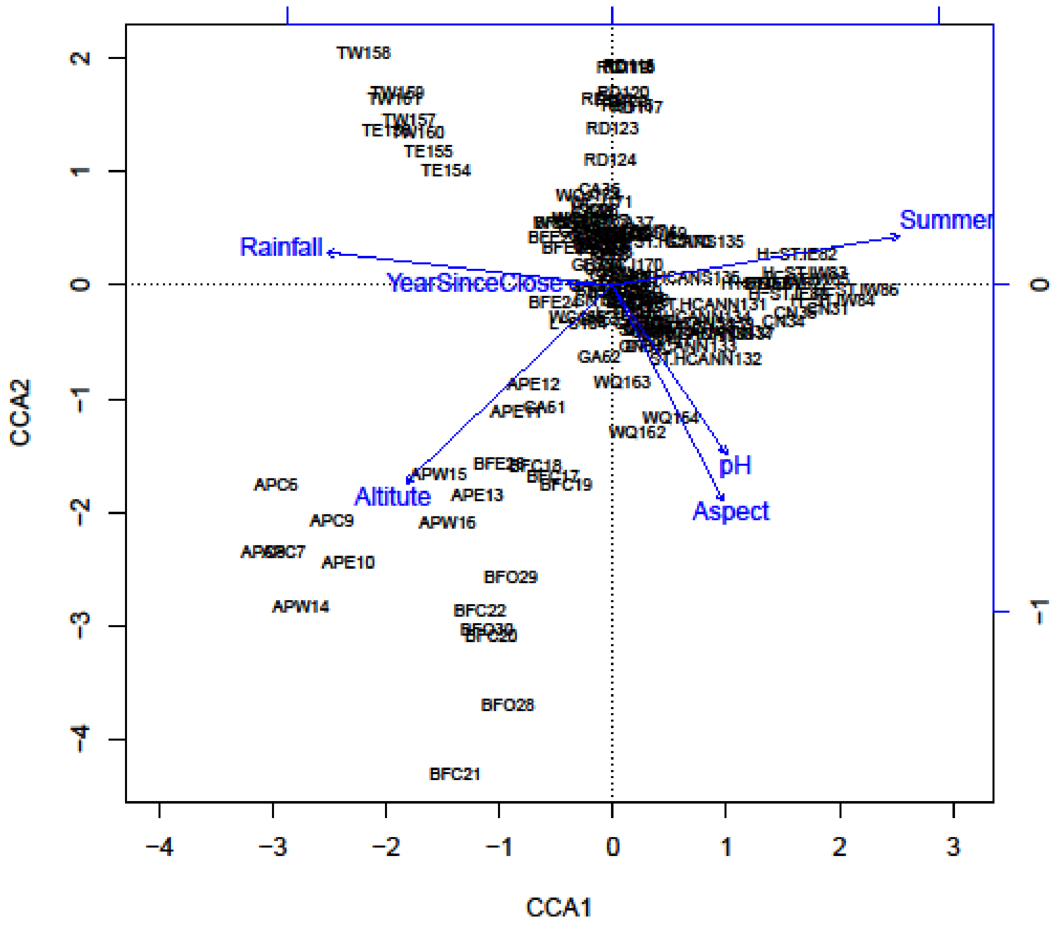

Figure 4.7 CCA of each relevé with rainfall, altitude, time since closure, pH, aspect and summer temperature, showing that rainfall, altitude, summer temperature, aspect and pH are important components

Comparing the climatic factors, time, soil and pH imposes structure on the biplot. While most sites cluster centrally, the Trecwn sites (TE & TW), are distinct as are the majority of the Appleby sites (APW, APC & APE). These are associated with the higher rainfall and altitude vectors (Figure 4.7). These are important vectors, determined by length of arrow, as are summer temperature, aspect and pH. Time since closure is of little importance. The significance of the vectors is considered with Fig 4.9 and Table 4.4 below.

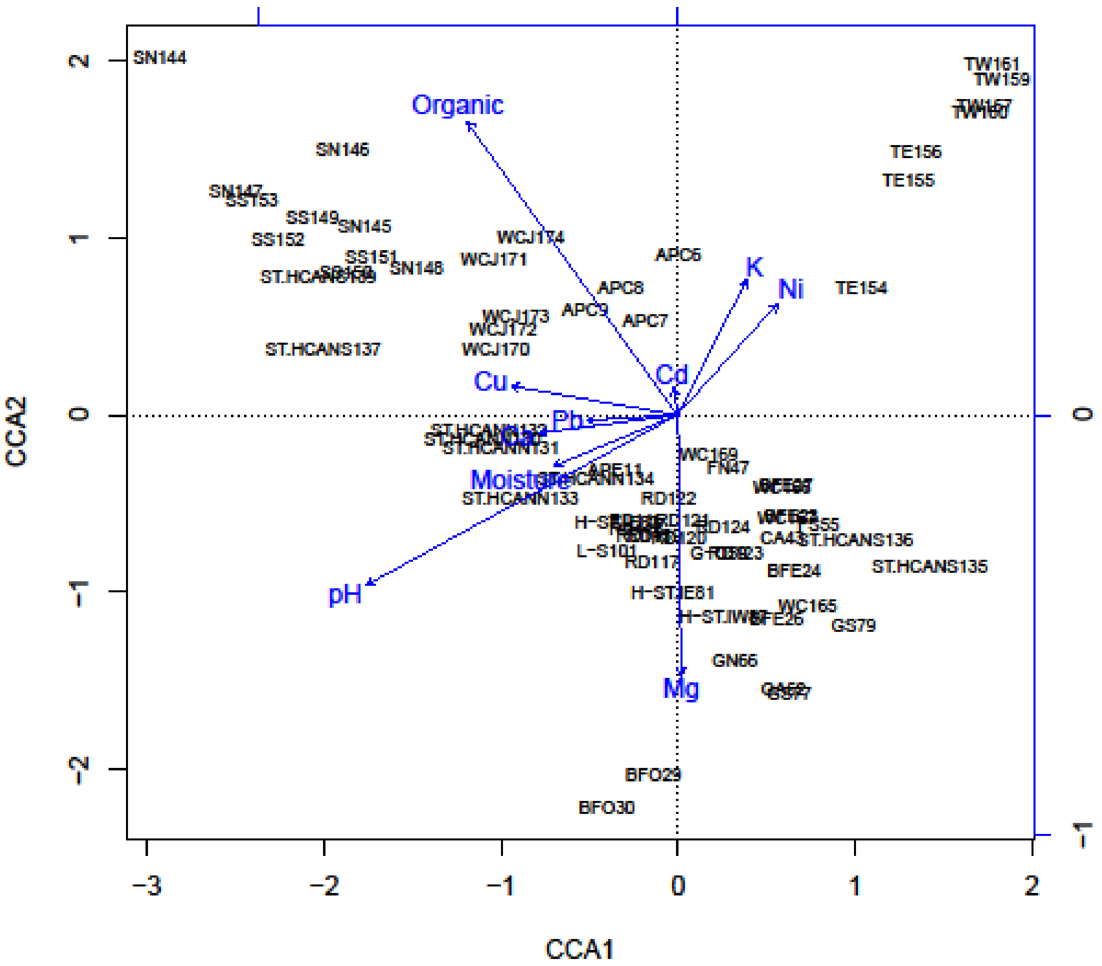

Figure 4.8 CCA of each relevé with pH, moisture, organic content and heavy metals, showing that organic content, pH and Magnesium are major components

The soil CCA biplot (Figure 4.8), shows that the major components are organic content, pH and Magnesium (Mg) content, with the remaining metal ions and moisture of similar but low impact. Soil characters lead to clustering of the Trecwn sites (TE & TW) and the St. Helens North relevés (SN) with some of the St. Helens Canal South relevés (ST.HCANS). Woodthorpe Colliery Junction (WCJ) and Appleby Cutting (APC) cluster together. The significance of the vectors is considered with Fig 4.10 and Table 4.5 below.

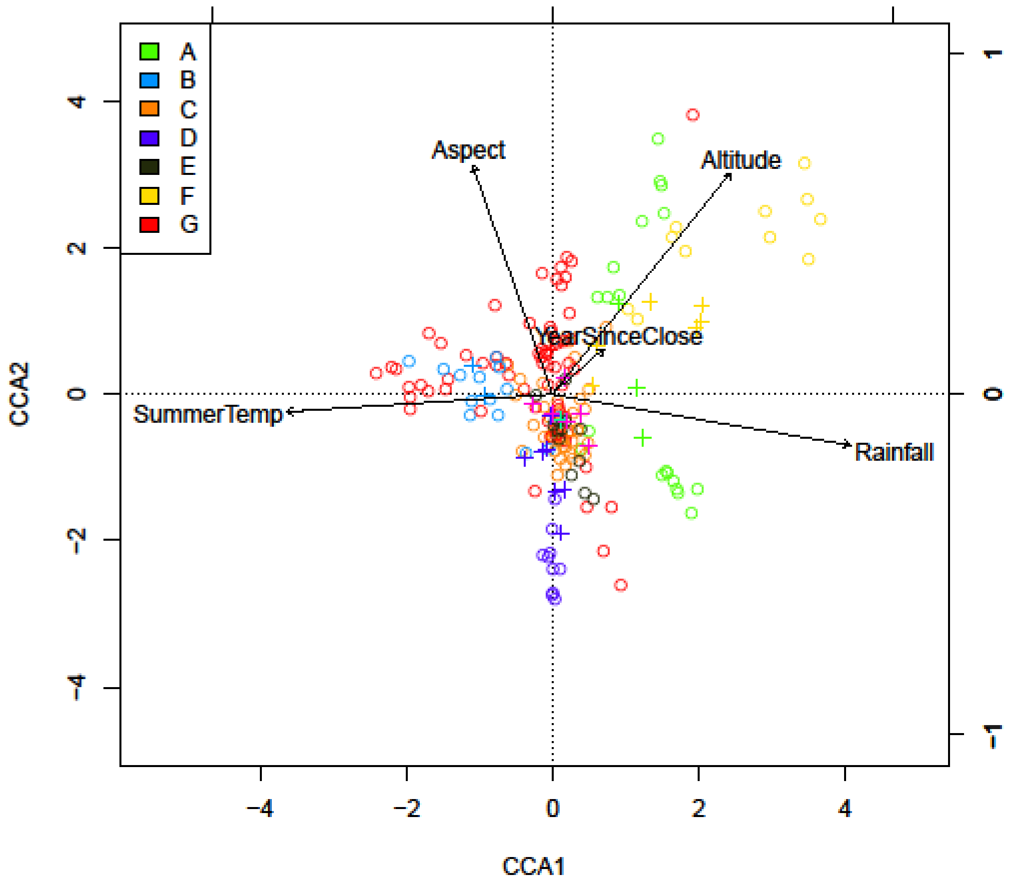

Figure 4.9 CCA of the seven clusters against altitude, aspect, year since abandonment (YearSinceClose), rainfall and summer temperature, showing altitude, aspect, summer temperature and rainfall are significant

	Df	Chisq	F	N.Perm	Pr(>F)
Altitude	1	0.3304	3.7291	99	0.01 **
Aspect	1	0.2639	2.9784	99	0.01 **
YearSinceClose	1	0.1397	1.5772	99	0.21
Rainfall	1	0.3495	3.9449	99	0.01 **
SummerTemp	1	0.3175	3.5830	99	0.01 **
Residual	168	14.8852			

Significance codes: ** p=0.01 No asterisk = NS

Table 4.4 Permutation test for CCA plot Fig 4.9 under reduced fit model (Terms added sequentially; first to last).

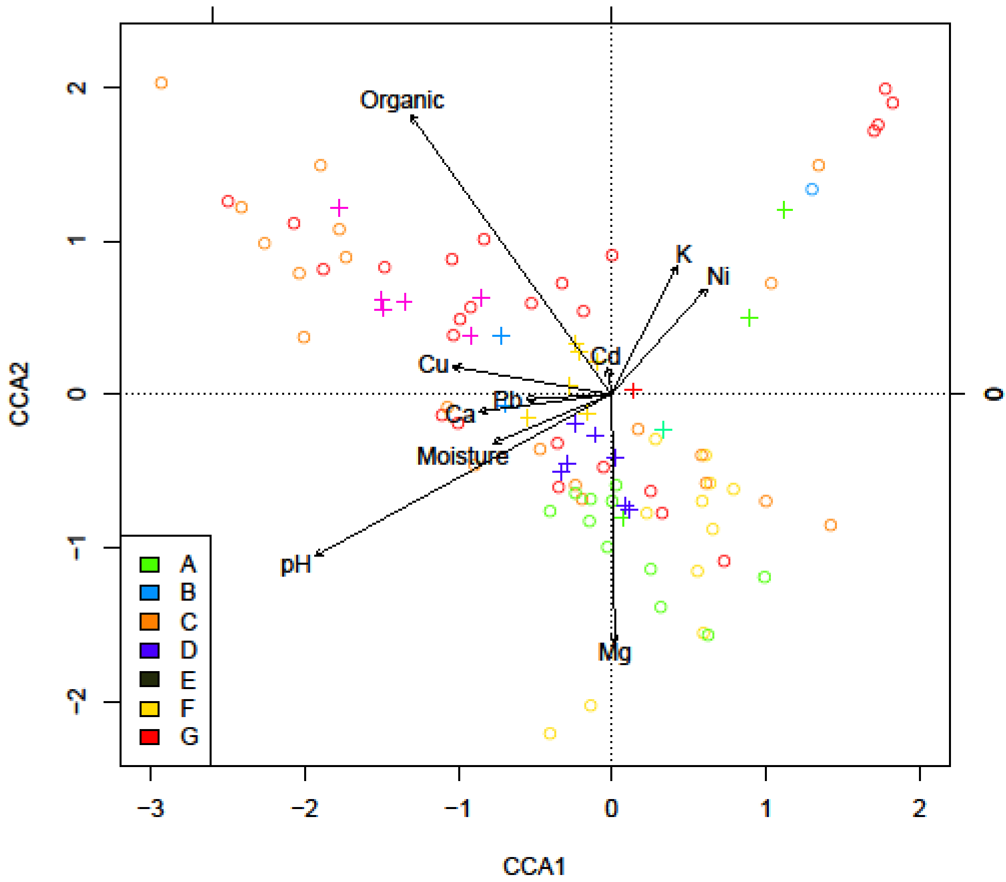

Figure 4.10 CCA of the seven clusters against pH, moisture, organic content, Mg, Pb, K, Ca, Cu, Cd, Ni, showing that pH, organic matter and Magnesium are significant with Nickel being less significant

	Df	Chisq	F	N.Perm	Pr(>F)
pH	1	0.3875	2.8529	99	0.01 **
Moisture	1	0.1507	1.1100	99	0.36
Organic	1	0.3853	2.8371	99	0.01 **
Mg	1	0.3202	2.3574	99	0.01 **
Pb	1	0.1786	1.3154	99	0.29
K	1	0.1959	1.4421	99	0.22
Ca	1	0.1568	1.1548	99	0.30
Cu	1	0.2038	1.5003	99	0.22
Cd	1	0.0575	0.4231	99	0.87
Ni	1	0.2257	1.6620	99	0.04 *
Residual	57	7.7413			

Significance codes: ** p=0.01; *p=0.05, No asterisk = NS

Table 4.5 Permutation test for CCA plot Fig 4.10 under reduced fit model (Terms added sequentially; first to last).

When considered as clusters (or communities) rather than individual relevés, the communities are not randomly distributed within the biplots. Relevés from the same community, identified by the same colour on the biplots, generally cluster together, although there is some overlap with adjacent clusters and towards the centre, while Cluster G is broadly spread. This is seen in both the abiotic and time since abandonment plot (Figure 4.9) and the soil plot (Figure 4.10), although the soil biplot shows a more diffuse pattern within clusters than the abiotic values. Statistical analysis of environmental and temporal CCA shows that altitude, aspect, rainfall and summer temperature are all significantly associated with the vegetation data. Year since closure is not associated with the vegetation data. In the soil factors CCA, pH, organic content, Magnesium content and Nickel content are all significantly associated with the vegetation separation. All other factors (moisture content, Pb, K, Ca, Cu and Cd) show no significant relationship with the vegetation data.

Once soil factors, time and abiotic factors are combined in the CCA plot (Figure 4.11) the abiotic values show a greater impact than the soil factors. Statistical analysis (Table 4.6) adds time since abandonment to the list of factors significantly associated with the vegetation data listed above and in Tables 4.4 and 4.5 (altitude, aspect, rainfall and summer temperature, pH, organic content, Magnesium content and Nickel content).

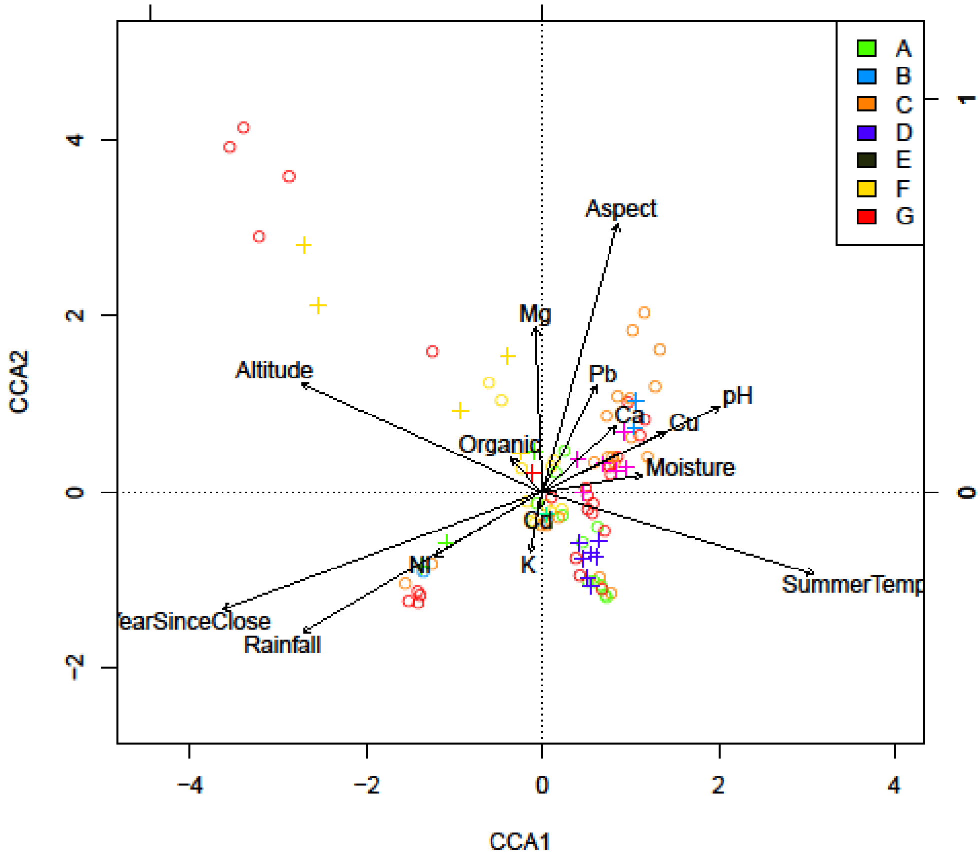

Figure 4.11 CCA of the seven clusters against all of the variables tested, showing the greater impact of the abiotic values compared to the soil values. Time since abandonment also becomes significant

	Df	Chisq	F	N.Perm	Pr(>F)
Altitude	1	0.4650	3.9116	99	0.01 **
Aspect	1	0.3725	3.1333	99	0.01 **
YearSinceClose	1	0.4513	3.7963	99	0.01 **
Rainfall	1	0.3136	2.6379	99	0.01 **
SummerTemp	1	0.3742	3.1479	99	0.01 **
pH	1	0.2474	2.0809	99	0.01 **
Moisture	1	0.1123	0.9450	99	0.51
Organic	1	0.3290	2.7672	99	0.01 **
Mg	1	0.2506	2.1083	99	0.01 **
Pb	1	0.1268	1.0666	99	0.45
K	1	0.1988	1.6724	99	0.08 .
Ca	1	0.1493	1.2563	99	0.25
Cu	1	0.1582	1.3308	99	0.22
Cd	1	0.0552	0.4644	99	0.90
Ni	1	0.2175	1.8298	99	0.05 *
Residual	52	6.1816			

Significance codes: **p= 0.01,*p= 0.05, No asterisk = NS

Table 4.6 Permutation test for CCA plot Fig 4.11 under reduced fit model (Terms added sequentially; first to last)

4.4 DISCUSSION

Under the traditional model of succession determined by a transition from extreme tolerant species to competitive types, it is predicted that species richness and species diversity would both increase over time following abandonment, before declining as trees begin to dominate, allowing only shade tolerant species to persist in the ground flora. This view is based upon studies of pioneer vegetation on other substrates, such as sand dunes (e.g. Pye *et al*, 2007). Furthermore as time progresses soil development would lead to increased nutrient levels resulting in higher Ellenberg N and F scores. This has not happened in this study. There is no simple temporal pattern with species richness, species diversity or soil factors. Rather, these all exhibit a random pattern with respect to time since abandonment. This may be because the time since abandonment is relatively short. However with these results it is tempting to consider that succession as studied here is a random and unpredictable process, where the environmental variables, edaphic variables and species life strategies are extremely variable and likely to change in different localities. A view shared by Walker & del Moral (2003) and Pickett *et al* (2008). Similar patterns have been found in forest communities (Wardle *et al*, 2004), and volcanic communities (del Moral, 2007)) although these were over a much longer timescale.

However the cluster analysis in the previous chapter revealed some distinct communities with indicator species significantly associated with them. Hence it may be appropriate to consider the data at the community level. Significant differences between communities are revealed in some of the abiotic factors (altitude, aspect, mean rainfall and mean summer temperature). Time for development is also significantly different as are some edaphic factors (pH, moisture content, organic content and Ca content), although the majority of edaphic factors show no significant differences. However while ANOVA is generally considered a robust statistical tool the markedly unequal variances in many of the measures mean that the ANOVA results may not be particularly reliable. Therefore the multivariate analysis is potentially the most informative.

Multivariate analysis reveals that there are some key factors separating the communities. These are mainly abiotic (rainfall, summer temperature, moisture). Soil factors are of less importance, only pH, organic content, Mg and Ni content are of significance (Fig 4.10). When considered alongside only abiotic factors time since abandonment is not significant (Fig 4.9). However when included with soil factors it becomes a significant agent separating the clusters (Fig 4.11). It is possible that time is an important factor on soil development. Indeed, on a study of succession on disused coal mines, time since closure and pH were significant factors affecting the plant community composition when the substrate had been covered with top-soil. Where no top-soil is present, the substrate limited succession (Alday *et al*, 2011). Other studies have shown mean annual temperature and mean annual rainfall to affect community composition in arable weed communities, with pH being less of an significant factor (Cimalová & Lososová, 2009). Similar to this study, a strong correlation between organic content and pH was discovered during a study of the vegetation communities along an Ethiopian river corridor (Tikssa *et al*, 2009).

It is of course possible that not all important architects of community composition were included in this study. General climatic conditions in an area have been used in the analysis when specific local conditions may be more relevant. For instance, the nature of a railway line, whether in a cutting or on an embankment may influence both climate and seed rain (Vitousek & Matsom, 1991 and Matlack, 1994). Surrounding land use may also be a factor in the colonisation of the ballast. Many of the railway lines sampled ran through rural areas, where permanent pasture was the neighbouring habitat with little source of seeds. By comparison those sampled in urban areas where unmanaged rank grassland occurred on the fringes may provide a more abundant source of propagules.

While there are species significantly associated with the clusters identified in Chapter three, the associations are not fixed and fidelity and exclusivity are rarely both strong for any given species. This indicates a random element to some of the community composition. Nevertheless clustering into distinct communities does occur and some of this clustering is associated with particular abiotic and edaphic factors along with time since development. This implies that given certain conditions there is a predictability to the community composition. However, no recent ecological work has emerged to support this view, particularly on synanthropic habitats.

CHAPTER 5 – CONSERVATION VALUE AND SUMMARY

5.1 SPECIES AND CONSERVATION VALUE

Across all sites, the study recorded a total of 278 species (including 11 taxa identified to species level only) (Table 5.1). This includes both vascular plants and bryophytes.

TABLE 5.1 SPECIES LIST FROM ALL RAILWAY SITES SHOWING THE CONSERVATION DESIGNATION OF EACH SPECIES (JNCC, 2015)

SPECIES	CONSERVATION DESIGNATION
Pteridium aquilinum	Common
Acer pseudoplatanus	Common
Achillea millefolium	Common
Agrimonia eupatoria	Common
Agrostemma githago	Common
Agrostis capillaris	Common
Agrostis stolonifera	Common
Aira caryophyllea	Common
Alliaria petiolata	Common
Alnus glutinosa	Common
Alnus incana	Common
Alopecurus pratensis	Common
Amblystegium serpens	Common
Anagallis arvensis	Common
Angelica sylvestris	Common
Anisantha sterilis	Common
Anthoxanthum odoratum	Common
Anthriscus sylvestris	Common
Arabidopsis thaliana	Common
Arctium minus	Common
Arenaria serpyllifolia	Common
Arrhenatherum elatius	Common
Artemisia absinthium	Common
Artemisia vulgaris	Common
Asplenium adiantum-nigrum	Common
Asplenium ruta-muraria	Common
Asplenium trichomanes	Common
Athyrium filix-femina	Common
Atrichum undulatum	Common
Ballota nigra	Common
Barbarea vulgaris	Common
Barbula convoluta	Common

Barbula recurvirostra	Common
Barbula unguiculata	Common
Bellis perennis	Common
Berberis vulgaris	Common
Betula pendula	Common
Betula pubescens	Common
Blackstonia perfoliata	Common
Brachypodium sylvaticum	Common
Brachythecium rivulare	Common
Brachythecium rutabulum	Common
Bromus hordeaceus	Common
Bryoerythrophyllum recurvirostrum	Common
Bryum argenteum	Common
Bryum caespiticium	Common
Bryum capillare	Common
Buddleja davidii	Common
Calliergonella cuspidata	Common
Calluna vulgaris	Common
Calystegia sepium	Common
Campylopus introflexus	Common
Cardamine flexuosa	Common
Cardamine hirsuta	Common
Carex flacca	Common
Catapodium rigidum	Common
Centaurea nigra	Common
Centaurium erythraea	Common
Cerastium fontanum	Common
Cerastium glomeratum	Common
Ceratodon purpureus	Common
Chaenorhinum minus	Common
Chamerion angustifolium	Common
Chenopodium polyspermum	Common
Cirsium arvense	Common
Cirsium palustre	Common
Cirsium vulgare	Common
Cladeonia sp.	Common
Convolvulus arvensis	Common
Conyza canadensis	Common
Corylus avellana	Common
Crataegus monogyna	Common
Crepis capillaris	Common
Crepis vesicaria	Common
Cupressus macrocarpa x Chamaecyparis nootkatensis	Common
Cymbalaria muralis	Common
Cynosurus cristatus	Common
Dactylis glomerata	Common
Daucus carota	Common

Deschampsia cespitosa	Common
Deschampsia flexuosa	Common
Dicranum scoparium	Common
Digitalis purpurea	Common
Dipsacus fullonum	Common
Dryopteris filix-mas	Common
Dyopteris felix-femina	Common
Echium vulgare	Common
Elytrigia repens	Common
Epilobium ciliatum	Common
Epilobium hirsutum	Common
Epilobium montanum	Common
Epilobium palustre	Common
Epilobium parviflorum	Common
Epilobium sp.	Common
Epilobium tetragonum	Common
Equisetum arvense	Common
Erigeron acer	Common
Eupatorium cannabinum	Common
Euphrasia officinalis agg.	Common
Eurhynchium praelongum	Common
Festuca ovina	Common
Festuca pratensis	Common
Festuca rubra	Common
Filipendula ulmaria	Common
Fragaria vesca	Common
Fraxinus excelsior	Common
Galium aparine	Common
Galium mollugo	Common
Galium palustre	Common
Galium parisiense	Nationally Scarce
Galium saxatile	Common
Galium verum	Common
Geranium dissectum	Common
Geranium molle	Common
Geranium robertianum	Common
Geum rivale	Common
Geum urbanum	Common
Glechoma hederacea	Common
Grimmia pulvinata	Common
Hedera helix	Common
Heracleum sphondylium	Common
Hieracium sp.	Common
Hieracium umbellatum	Common
Holcus lanatus	Common
Hypericum humifusum	Common
Hypericum montanum	IUCN Lower Risk (Near Threatened)

Hypericum perforatum	Common
Hypericum pulchrum	Common
Hypericum tetrapterum	Common
Hypnum cupressiforme	Common
Hypochaeris radicata	Common
Ilex aquifolium	Common
Impatiens glandulifera	Common
Juncus articulatus	Common
Juncus bufonius	Common
Juncus effusus	Common
Kindbergia praelonga	Common
Knautia arvensis	Common
Lactuca serriola	Common
Lamium album	Common
Lamium purpureum	Common
Lapsana communis	Common
Lathyrus pratensis	Common
Laylandii	Common
Leontodon autumnalis	Common
Leontodon hispidus	Common
Leucanthemum vulgare	Common
Leycesteria formosa	Common
Linaria vulgaris	Common
Linum catharticum	Common
Lolium perenne	Common
Lonicera pericyclamen	Common
Lophocolea sp.	Common
Lotus corniculatus	Common
Luzula campestris	Common
Luzula multiflora	Common
Luzula sylvatica	Common
Lycopus europaeus	Common
Matricaria discoidea	Common
Medicago lupulina	Common
Melilotus officinalis	Common
Mercurialis perennis	Common
Molinia caerulea	Common
Myosotis arvensis	Common
Myosotis discolor	Common
Nardus stricta	Common
Odontites vernus	Common
Oenothera biennis	Common
Oenothera cambrica	Common
Origanum vulgare	Common
Pastinaca sativa	Common
Peltigera sp.	Common
Phalaris arundinacea	Common

Phleum pratense	Common
Picris echioides	Common
Pilosella officinarum	Common
Pimpinella saxifraga	Common
Plantago lanceolata	Common
Plantago major	Common
Poa annua	Common
Poa pratensis	Common
Poa pratensis ag.	Common
Poa trivialis	Common
Polygonum aviculare	Common
Polytrichum commune	Common
Polytrichum commune v. commune	Common
Potentilla erecta	Common
Potentilla reptans	Common
Potentilla sterilis	Common
Primula vulgaris	Common
Prunella vulgaris	Common
Prunus sp.	Common
Pseudocrossidium hornschuchianum	Common
Pulicaria dysenterica	Common
Quercus robur	Common
Racometrium sp.	Common
Ranunculus acris	Common
Ranunculus bulbosus	Common
Ranunculus repens	Common
Reseda luteola	Common
Rhododendron ponticum	Common
Rhytidiadelphus squarrosus	Common
Ribes sp.	Common
Rosa arvensis	Common
Rosa canina	Common
Rosa pimpinellifolia	Common
Rosa sp.	Common
Rosa spinosissima	Common
Rubus fruticosus agg.	Common
Rubus idaeus	Common
Rumex acetosa	Common
Rumex acetosella	Common
Rumex conglomeratus	Common
Rumex crispus	Common
Sagina procumbens	Common
Salix caprea	Common
Salix cinerea	Common
Salix sp.	Common
Sambucus nigra	Common
Sanguisorba minor	Common

Schistidium apocarpum	Common
Schistidium crassipilum	Common
Scorzoneroides autumnalis	Common
Scrophularia auriculata	Common
Scrophularia nodosa	Common
Sedum acre	Common
Sedum rupestre	Common
Senecio jacobaea	Common
Senecio squalidus	Common
Senecio viscosus	Common
Senecio vulgaris	Common
Solanum dulcamara	Common
Solidago canadensis	Common
Sonchus arvensis	Common
Sonchus asper	Common
Sonchus oleraceus	Common
Sorbus aucuparia	Common
Stachys sylvatica	Common
Stellaria media	Common
Succisa pratensis	Common
Tanacetum vulgare	Common
Taraxacum officinale agg.	Common
Teucrium scorodonia	Common
Thuidium tamariscinum	Common
Tortula muralis	Common
Tragopogon pratensis	Common
Trifolium campestre	Common
Trifolium dubium	Common
Trifolium micranthum	Common
Trifolium pratense	Common
Trifolium repens	Common
Tripleurospernum inodorum	Common
Trisetum flavescens	Common
Tussilago farfara	Common
Ulex gallii	Common
Ulota crispa agg.	Common
Urtica dioica	Common
Vaccinium myrtillus	Common
Valeriana officinalis	Common
Verbascum thapsus	Common
Verbena officinalis	Common
Veronica arvensis	Common
Veronica beccabunga	Common
Veronica chamaedrys	Common
Veronica officinalis	Common
Veronica persica	Common
Vicia bithynica	Nationally Scarce

Vicia cracca	Common
Vicia hirsuta	Common
Vicia orobus	Nationally Scarce
Vicia sativa	Common
Vicia sepium	Common
Vicia tetrasperma	Common
Viola arvensis	Common
Viola canina	IUCN Lower Risk (Near Threatened)
Viola riviniana	Common
Viola sp.	Common
Vulpia bromoides	Common

This list included three species which are classified as Nationally Scarce (taxa which occur in 26-100 hectads in Great Britain); *Galium parisiense*, found in one relevé at St. Helens Canal North; *Vicia bithynica*, found in one relevé at Trecwn West and *Vicia orobus*, found in two relevés at Trecwn West. Two species classified as IUCN Lower Risk (Near Threatened) were also recorded; *Hypericum montanum*, found in two relevés at St. Helens Canal North and *Viola canina*, found in one relevé at Cambridge, one relevé at Leek to Stoke and two relevés at Histon to St.Ives West. IUCN Lower Risk taxa are based on recent declines in population size and distribution (JNCC). There were no species recorded at the higher IUCN conservation categories. Despite the presence of these Nationally Scarce or Near Threatened species none of the sites would receive statutary conservation protection based upon the species present.

Specific criteria are used for designating nature conservation sites, such as a Site of Special Scientific Interest (SSSI) or a Local Wildlife Site (LWS). For SSSIs a number of parameters are assessed per site, including size, diverisity, naturalness, rairity, fragility, typicalness and potential value

(Ratcliffe, 1977). It is very difficult to apply these critiera to the railway line sites. For example, rarity could not be used as a criteria as <2% of the total species found are considered to be rare. Likewise the assemblages at each site consist of a mix of common species. Hence they would not receive national legal protection for this reason either.

At a local, non-statutory, level LWS criteria tends to be based on species assemblages, with a defined number of species required per habitat type to allow designation. The indicator species are typically of established habitats such as grassland, woodland etc. Given the assemblages described here are all ephemeral ruderal communities which rarely feature in LWS criteria, the assemblages recorded would not lead to protection of any of the sites in this study. The distinctive community identified in this study; *Arrhenatherum elatius* with a ruderal component, which is not documented in any published statutory and non-statutory guidelines and is likely to be widespread in other ex-industrial habitats.

5.2 ADDRESSING OF AIMS

This study has focussed on elements of phytosociology using a simple synanthropic community. It had the following aims.

1. Firstly, to survey and describe plant communities found on disused railway ballast in the UK, based on floristic data only and using a British approach (NVC) and to identify any previously undescribed communities.

2. Secondly, to survey and describe the plant communities found using a the modified Braun-Blanquet method,
3. Thirdly, to analyse the floristic data with environmental, temporal and edaphic variables as a factor, in an attempt to identify what determines the community composition and whether communities are random or can be predicted along a successional process.
4. Finally to consider the potential conservation value of disused railway lines considering both rare species and species assemblages.

Chapter 1 described the background to phytosociology in Europe, from the late 19th Century to the present day. The different pathways of ecological schools of thought were examined, with a discussion on the convergent thoughts of British ecologists, compared to continental ecologists. Similarly, gaps in coverage of synanthropic habitat studies were identified. Synanthropic vegetation has long been studied on the continent but far less frequently considered in the UK. The NVC has large gaps regarding communities found on ex-industrial land (Rodwell *et al*, 2000), whereas databases on the continent support large numbers of relevés from such habitats and individual books are published devoted to ruderal plant communities (e.g. Chytrý, 2009). Railway lines are an easy subject to study. They are linear, constructed in the same way throughout the UK and time since abandonment is easy to discover. Likewise other potential abiotic factors. Continental ecologists have long studied railway vegetation. The UK has few such studies. This work has filled this gap.

Chapter 2 examined the plant communities found on the railway lines by using the NVC approach. All relevés were sorted into NVC tables and constant species established. The communities were analysed using MAVIS and by hand using the NVC publications. Correspondence Analysis was used on the communities and on typical NVC communities, to find similarities. Few similarities were found with published NVC communities. A large number of communities had affinities with MG1 Arrhenatherum elatius grassland but with un-described sub-communities, with ruderal species as main components or woody and scrub species as components. Similarly, a number of communities had affinities to OV communities but with different constant species. It became clear that it is difficult to apply the NVC to synanthropic habitats and that there are ruderal communities in existence that are not described in the NVC. In particular this study identified a new community, that of a Arrhernatherum elatius community with a sub-community of ruderal species as main components, with a suggested classification as MG14.

Other NVC communities exhibit a single dominant species across a number of communities, for example, Quercus woodlands and it is the associated vegetation and its physiognomy that merit differentiation. Given the associated species found in this study within the *Arrhenatherum elatius* dominated grassland are very different from that described by Rodwell (1992) for MG1, with short lived ruderal species rather than perennials, and that the physiognomy is also markedly different, I consider that the community described here constitutes a new Arrhenatheretum, previously undescribed from the UK.

Chapter 3 utilised a modified Braun-Blanquet approach to analysing the vegetation data. The Br-Bl method is widely used outside the UK, whereas within Britain it has rarely been applied. Multivariate analysis revealed no clear identifiable and separate clusters, however hierarchical cluster analysis revealed clear splits in the data. Species characteristic of each cluster were identified using Indicator Values. A total of seven clusters were identified from the floristic data with distinctive indicator species. The major cluster, is dominated by *Arrhenatherum elatius*, with a ruderal component and a lack of umbellifers. A large set of clusters had strong ruderal components or woody components, which is similar to the NVC findings.

Chapter 4 investigated the potential contribution of environmental, temporal and edaphic variables on each of the sites and clusters identified in the previous chapter. This was underpinned by a theoretical question as to the nature of vegetation dynamics. Successional processes have long been presented as simple temporal progression as one group of species replaces another based upon the characteristics of the species, for instance ruderal through to biannual and perennial forbs and grasses ending in a tree dominated climax community. The more modern approach is to view the process as much more stochastic. The synanthropic communities here which are of varying ages represent a unique opportunity to address this question. Are the predominantly ruderal communities identified here a random amalgamation of plants or as a series of predictable successional communities determined by temporal, abiotic and edaphic factors.

A number of factors potentially influencing community composition were incorporated into the study. These included abiotic factors; summer temperature, rainfall, altitude and aspect and edaphic factors; pH, moisture content, organic content, metal ion content and time since abandonment. Soil nutrient level was also investigated using Ellenberg indicator values. Simple investigation of the impact of time on species richness, diversity and soil nutrient level revealed no relationship either at the individual relevé or at the clusters identified in the previous chapter. CCA analysis was more revealing showing that rainfall, summer temperature and moisture were an important part of community composition with soil factors such as Lead and Potassium having no significant impact. Time since abandonment only becomes significant when it is combined with soil factors. This suggests that community composition is not entirely random in these communities. No similar studies have been undertaken which address the nature of early successional processes in synanthropic habitats. Thus this study is a significant contribution to the literature.

Chapter five above highlighted that there is little chance of these sites being protected by conservation legislation, although the value of such sites to pollinators with their long flowering season and to other invertebrates with their lack of disturbance is recognised.

5.3 FURTHER WORK

The major findings of this study are the discovery of new plant communities within the UK and an understanding of successional processes on synanthropic habits. Several lines of further work then develop from these discoveries. These suggestions would all be original contributios to the literature.

1. To revisit extant disused lines and to repeat the survey undertaken here, thus revealing the nature of temporal changes at particular sites. This would contribute to understanding the nature of succession at synanthropic sites.
2. To describe and analyse the vegetation at different synanthropic habitats, particularly other ex-industrial sites. This would identify whether the communities identified in chapter three are more widespread or restricted to disused railway lines. Thus to determine the extent of the additional communities described herein.
3. In addition, ex-industrial sites have potential value for invertebrate communities. Through observations undertaken during this study and professional experience elsewhere hymenoptera and coleoptera are regularly observed. It would be worthwhile investigating the invertebrate communities and the ecological principles that underpin them within these habitats.

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APPENDIX 1 - RAW DATA – ON ATTACHED DISK

Table number	Type	Ellenberg Indicator Value		1	2	3	4	5	6	7	8	9
Relevé number	Type	**F**	**N**	1	2	3	4	5	6	7	8	9
SITE ID CODE				**AM**	**AM**	**AM**	**AM**	**AM**	**APC**	**APC**	**APC**	**APC**
Cover abundance scale				01	01	01	01	01	01	01	01	01
Date (year/month/day)				20090716	20090716	20090716	20090716	20090716	20090713	20090713	20090713	20090713
Altitude (m)				50	50	50	50	50	160	160	160	160
Aspect (degrees)				30	30	30	30	30	0	340	330	335
Cover total (%)				40	80	50	50	40	25	25	30	20
Cover herb layer (%)				0	0	0	0	0	0	0	0	0
Maximum height herbs (cm)				0	0	0	0	0	0	0	0	0
Mosses identified (y/n)				Y	Y	Y	Y	Y				
Pteridium aquilinum	hl	5	3	1	0	0	0	0	0	0	0	0
Stellaria media	hl	5	7	1	0	0	0	0	0	0	0	0
Rubus fruticosus agg.	hl	6	6	30	16	10	4	4	0	0	0	0
Epilobium hirsutum	hl	8	7	1	0	0	0	0	0	0	0	0
Epilobium palustre	hl	8	3	2	0	0	0	0	0	0	0	0
Geranium robertianum	hl	6	6	6	1	1	0	0	4	2	1	0
Hedera helix	hl	5	6	4	4	4	4	2	0	0	0	0
Plantago lanceolata	hl	5	4	2	1	2	0	16	0	0	0	0
Leontodon hispidus	hl	4	3	1	1	0	0	0	0	0	0	0
Taraxacum officinale agg.	hl	5	6	1	0	0	0	0	0	0	0	0
Senecio jacobaea	hl	4	4	1	1	1	1	1	0	0	0	0
Festuca rubra	hl	5	5	1	1	0	1	1	0	0	0	0
Lolium perenne	hl	5	6	1	0	1	0	0	0	1	0	0
Dactylis glomerata	hl	5	6	1	2	8	4	1	0	0	0	0
Arrhenatherum elatius	hl	5	7	4	2	2	2	1	0	0	0	0
Deschampsia cespitosa	hl	6	4	3	0	0	0	0	0	0	0	0
Holcus lanatus	hl	6	5	2	4	4	2	0	0	0	0	0
Anthoxanthum odoratum	hl	6	3	16	24	30	20	12	0	0	0	0
Agrostis capillaris	hl	5	4	1	12	0	4	8	0	0	0	0
Agrostis stolonifera	hl	6	6	2	0	0	0	0	0	0	0	0
Brachythecium rutabulum	ml			1	0	1	0	4	0	0	0	0
Bryum capillare	ml			1	1	0	0	0	0	0	0	0
Polytrichum commune v. commune	hl			2	0	0	8	6	0	0	0	0
Schistidium crassipilum	ml			1	2	0	0	1	10	12	16	8
Epilobium parviflorum	hl	9	5	0	1	0	0	0	0	0	1	0
Veronica officinalis	hl	5	4	0	1	0	0	0	0	0	0	0
Atrichum undulatum	ml			0	1	4	8	0	0	0	0	0
Campylopus introflexus	ml			0	1	1	4	6	0	0	0	0
Linaria vulgaris	hl	4	6	0	0	1	1	1	0	0	0	0
Lotus corniculatus	hl	4	2	0	0	0	1	0	0	0	0	0
Carex flacca	hl	5	2	0	0	0	1	0	0	0	0	0
Ceratodon purpureus	ml			0	0	0	2	0	0	0	0	0
Equisetum arvense	hl	6	6	0	0	0	0	1	0	0	0	0
Rumex acetosa	hl	5	4	0	0	0	0	1	0	1	0	0
Epilobium montanum	hl	6	6	0	0	0	0	1	2	2	1	4
Hypericum pulchrum	hl	5	3	0	0	0	0	0	1	0	0	0
Cardamine flexuosa	hl	7	6	0	0	0	0	0	2	20	4	4

APPENDIX 2 - R CODING

```
#Code for analysis of vegetation data from disused railway lines

#28/02/14

#Robert Ashton

#Set working directory and import data and check it has been imported correctly
setwd("C:\\RFiles\\RailTrack\\PCA\\")
railData = read.csv(file = "ImportData.csv", stringsAsFactors = FALSE, header = TRUE, sep =
",", row.names = 1)
names(railData)
str(railData)
#Convert to matrix for use in metaMDS
mdsData = data.matrix(railData)
str(mdsData)
names(mdsData)


##Use vegan package
library(vegan)

#Perform NMDS
rail_NMDS = metaMDS(comm = mdsData, k = 2, trymax = 100, autotransform = FALSE)

#Sheperd Plot
pdf("sheperdplot.pdf")
stressplot(rail_NMDS)
dev.off()

#Removes numbers from row titles of railData for use in colouring
colUse = as.factor(gsub("\\d", "", row.names(railData)))
colCodes = c("#000000", "#FFFF00", "#1CE6FF", "#FF34FF", "#FF4A46", "#008941",
"#006FA6", "#A30059", "#FFDBE5", "#7A4900", "#0000A6", "#63FFAC", "#B79762",
"#004D43", "#8FB0FF", "#997D87", "#5A0007", "#809693", "#FF0800", "#1B4400",
"#4FC601", "#3B5DFF", "#4A3B53", "#FF2F80", "#61615A", "#BA0900", "#6B7900",
"#00C2A0", "#FFAA92", "#FF90C9", "#B903AA", "#D16100", "#DDEFFF", "#000035",
"#7B4F4B")
colCodes2 = rainbow(35)
colVec = colCodes[colUse]

#Scatter plots
pdf("sitesplot.pdf")
plot(rail_NMDS, display = "sites")
orditorp(rail_NMDS, display = "sites", col = colCodes[colUse], pch = 19, labels = FALSE)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

pdf("speciesplot.pdf")
plot(rail_NMDS, display = "species")
dev.off()
```

```
#PCA code

#Load FactoMineR package
library(FactoMineR)
#Conduct PCA
pca2 = PCA(mdsData, 2, scale.unit = FALSE)

pdf("PCAplot2axes.pdf")
plot.PCA(pca2, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()
pca2$eig

#Again with 4 pca axes
pca4 = PCA(mdsData, 4, scale.unit = FALSE)
pca4$eig
Axes 1 and 2
pdf("PCAplot4axes12.pdf")
plot.PCA(pca4, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 3
pdf("PCAplot4axes13.pdf")
plot.PCA(pca4, axes = c(1,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 4
pdf("PCAplot4axes14.pdf")
plot.PCA(pca4, axes = c(1,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 3
pdf("PCAplot4axes23.pdf")
plot.PCA(pca4, axes = c(2,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 4
pdf("PCAplot4axes24.pdf")
plot.PCA(pca4, axes = c(2,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 3 and 4
pdf("PCAplot4axes34.pdf")
plot.PCA(pca4, axes = c(3,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()
```

```
#03/04/14

######Hellinger standardisation#####
library(vegan)

helData = decostand(mdsData, "hellinger")

#Load FactoMineR package
library(FactoMineR)
#Conduct PCA
pca2 = PCA(helData, 2, scale.unit = FALSE)

pdf("helPCAplot2axes.pdf")
plot.PCA(pca2, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()
pca2$eig

#Again with 4 pca axes
pca4 = PCA(helData, 4, scale.unit = FALSE)
pca4$eig
#Axes 1 and 2
pdf("helPCAplot4axes12.pdf")
plot.PCA(pca4, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 3
pdf("helPCAplot4axes13.pdf")
plot.PCA(pca4, axes = c(1,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 4
pdf("helPCAplot4axes14.pdf")
plot.PCA(pca4, axes = c(1,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 3
pdf("helPCAplot4axes23.pdf")
plot.PCA(pca4, axes = c(2,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 4
pdf("helPCAplot4axes24.pdf")
plot.PCA(pca4, axes = c(2,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 3 and 4
pdf("helPCAplot4axes34.pdf")
```

```
plot.PCA(pca4, axes = c(3,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#####Data with 10% less ommitted#####

removeData = function(dataFrame, percentage) {
    species = colnames(dataFrame)
    releve = rownames(dataFrame)
    totalReleve = length(releve)
    totalVector = vector()
    for (x in 1:length(species)) {
        total = 0
        for (y in 1:totalReleve) {
            if (dataFrame[y,x] != 0) {
                total = total + 1
            }
        }
        totalVector[x] = total
    }
    counter = 0
    print(totalVector)
    removeIndex = NULL
    for (presentIn in totalVector) {
        counter = counter + 1
        if ((presentIn/totalReleve)*100 < percentage) {
            removeIndex =  c(removeIndex, -counter)
        }
    }
    if (is.null(removeIndex)){
        return(dataFrame)
    }
    else{
    return(dataFrame[ ,removeIndex])
    }
}

test = matrix( c(1,0,3,2,0,2,3,2,1), nrow = 3, ncol = 3)
colnames(test) = c(1,2,3)
rownames(test) = c(1,2,3)

###Change Data to data with insignicant 10% and perform PCA###

#Data
tenPerData = removeData(mdsData, 10)

library(FactoMineR)
#Conduct PCA
pca2 = PCA(tenPerData, 2, scale.unit = FALSE)

pdf("PCAplot2axesTenPercentFix.pdf")
plot.PCA(pca2, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1, xlim = c(-40, 50))
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()
pca2$eig

#Again with 4 pca axes
pca4 = PCA(tenPerData, 4, scale.unit = FALSE)
```

```
pca4$eig
#Axes 1 and 2
pdf("PCAplot4axes12TenPercent.pdf")
plot.PCA(pca4, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 3
pdf("PCAplot4axes13TenPercent.pdf")
plot.PCA(pca4, axes = c(1,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 4
pdf("PCAplot4axes14TenPercent.pdf")
plot.PCA(pca4, axes = c(1,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 3
pdf("PCAplot4axes23TenPercent.pdf")
plot.PCA(pca4, axes = c(2,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 4
pdf("PCAplot4axes24TenPercent.pdf")
plot.PCA(pca4, axes = c(2,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 3 and 4
pdf("PCAplot4axes34TenPercent.pdf")
plot.PCA(pca4, axes = c(3,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

###NMDS of 10% data###

library(vegan)

#Perform NMDS
rail_NMDS = metaMDS(comm = tenPerData, k = 2, trymax = 100, autotransform = FALSE)

#Sheperd Plot
pdf("sheperdplotTenPercent.pdf")
stressplot(rail_NMDS)
dev.off()

#Scatter plots
pdf("sitesplotTenPercent.pdf")
plot(rail_NMDS, display = "sites")
orditorp(rail_NMDS, display = "sites", col = colCodes[colUse], pch = 19, labels = FALSE)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
```

```
dev.off()

ordiplot(rail_NMDS, display = "species")
pdf("speciesplotTenPercent.pdf", height = 10, width = 10)
ordipointlabel(rail_NMDS, display = "species")
dev.off()

###Change Data to data with insignicant 20% and perform PCA###

#Data
twentyPerData = removeData(mdsData, 20)
#We don't want rows of zeros so remove these
twentyPerData = twentyPerData[rowSums(twentyPerData != 0) != 0, ]

library(FactoMineR)
#Conduct PCA
pca2 = PCA(twentyPerData, 2, scale.unit = FALSE)

pdf("PCAplot2axesTwentyPercent.pdf")
plot.PCA(pca2, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()
pca2$eig

#Again with 4 pca axes
pca4 = PCA(twentyPerData, 4, scale.unit = FALSE)
pca4$eig

#Axes 1 and 2
pdf("PCAplot4axes12TwentyPercent.pdf")
plot.PCA(pca4, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 3
pdf("PCAplot4axes13TwentyPercent.pdf")
plot.PCA(pca4, axes = c(1,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 4
pdf("PCAplot4axes14TwentyPercent.pdf")
plot.PCA(pca4, axes = c(1,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 3
pdf("PCAplot4axes23TwentyPercent.pdf")
plot.PCA(pca4, axes = c(2,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 4
pdf("PCAplot4axes24TwentyPercent.pdf")
```

```
plot.PCA(pca4, axes = c(2,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 3 and 4
pdf("PCAplot4axes34TwentyPercent.pdf")
plot.PCA(pca4, axes = c(3,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

###NMDS of 20% data###

library(vegan)

#Perform NMDS
rail_NMDS = metaMDS(comm = twentyPerData, k = 2, trymax = 100, autotransform =
FALSE)

#Sheperd Plot
pdf("sheperdplotTwentyPercent.pdf")
stressplot(rail_NMDS)
dev.off()

#Scatter plots
pdf("sitesplotTwentyPercent.pdf")
plot(rail_NMDS, display = "sites")
orditorp(rail_NMDS, display = "sites", col = colCodes[colUse], pch = 19, labels = FALSE)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

ordiplot(rail_NMDS, display = "species")
pdf("speciesplotTwentyPercent.pdf", height = 10, width = 10)
ordipointlabel(rail_NMDS, display = "species")
dev.off()

###Change Data to 30% and perform PCA###

#Data
thirtyPerData = removeData(mdsData, 30)
thirtyPerData = thirtyPerData[rowSums(thirtyPerData != 0) != 0, ]

library(FactoMineR)
#Conduct PCA
pca2 = PCA(thirtyPerData, 2, scale.unit = FALSE)

pdf("PCAplot2axesThirtyPercent.pdf")
plot.PCA(pca2, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()
pca2$eig

#Again with 4 pca axes
pca4 = PCA(thirtyPerData, 4, scale.unit = FALSE)
pca4$eig
#Axes 1 and 2
pdf("PCAplot4axes12ThirtyPercent.pdf")
```

```
plot.PCA(pca4, axes = c(1,2), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 3
pdf("PCAplot4axes13ThirtyPercent.pdf")
plot.PCA(pca4, axes = c(1,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 1 and 4
pdf("PCAplot4axes14ThirtyPercent.pdf")
plot.PCA(pca4, axes = c(1,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 3
pdf("PCAplot4axes23ThirtyPercent.pdf")
plot.PCA(pca4, axes = c(2,3), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 2 and 4
pdf("PCAplot4axes24ThirtyPercent.pdf")
plot.PCA(pca4, axes = c(2,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

#Axes 3 and 4
pdf("PCAplot4axes34ThirtyPercent.pdf")
plot.PCA(pca4, axes = c(3,4), choix = "ind", habillage = "ind", col.hab = colCodes[colUse],
label = "none", cex = 1.1)
legend("topright", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

###NMDS of 30% data###

library(vegan)

#Perform NMDS
rail_NMDS = metaMDS(comm = thirtyPerData, k = 2, trymax = 100, autotransform = FALSE)

#Sheperd Plot
pdf("sheperdplotThirtyPercent.pdf")
stressplot(rail_NMDS)
#dev.off()

#Scatter plots
pdf("sitesplotThirtyPercent.pdf")
plot(rail_NMDS, display = "sites")
orditorp(rail_NMDS, display = "sites", col = colCodes[colUse], pch = 19, labels = FALSE)
legend("topleft", legend = levels(colUse), fill = colCodes, cex = 0.69)
dev.off()

ordiplot(rail_NMDS, display = "species")
```

```
pdf("speciesplotThirtyPercent.pdf", width = 9)
ordipointlabel(rail_NMDS, display = "species")
dev.off()

#Rail Data for Ellenberg F and N plotting

#Robert Ashton
#01/06/14

setwd("C:\\RFiles\\RailTrack\\Ellenberg\\")
ellenbergData = read.csv(file = "EllenbergImport.csv", stringsAsFactors = FALSE, header =
TRUE, sep = ",")
names(ellenbergData)
str(ellenbergData)

abandonedTime = ellenbergData[247, c(-2,-1)]
ellenbergData = ellenbergData[-247, ]
ellenbergF = ellenbergData[ , 1]
ellenbergN = ellenbergData[ , 2]
ellenbergData = ellenbergData[ , 3:176 ]

#Fix abandoned since row
abandonedNo = c()
index = 1
for (x in abandonedTime){
  abandonedNo[index] = as.numeric(x)
  index = index +1
  }

#Ellenberg N mean
notZero = c()
index2 = 1
index3 = 1
ellenbergNAverage = c()
for (column in ellenbergData){
  for (value in column) {
    notZero[index2] = (value != 0)
    index2 = index2 + 1
  }
  ellenbergNAverage[index3] = mean(ellenbergN[notZero], na.rm = TRUE)
  index2 = 1
  index3 = index3 + 1
  notZero = c()
}

pdf("EllenbergNMeanFix.pdf")
plot(abandonedNo, ellenbergNAverage, xlab = "Time since abandonment (years)", ylab =
"Mean (unweighted) Ellenberg N value per releve")
dev.off()

#EllenbergN Weighted Mean
#29/07/14
notZero = c()
index2 = 1
index3 = 1
ellenbergNWeightAverage = c()
for (column in ellenbergData){
  for (value in column) {
    notZero[index2] = (value != 0)
    index2 = index2 + 1
```

```
    }
    ellenbergNWeightAverage[index3] = weighted.mean(ellenbergN[notZero], column[notZero],
na.rm = TRUE)
    index2 = 1
    index3 = index3 + 1
    notZero = c()
}

pdf("EllenbergNWeightMean.pdf")
plot(abandonedNo, ellenbergNWeightAverage)
dev.off()

#Ellenberg F mean
notZero = c()
index2 = 1
index3 = 1
ellenbergFAverage = c()
for (column in ellenbergData){
    for (value in column) {
        notZero[index2] = (value != 0)
        index2 = index2 + 1
    }
    ellenbergFAverage[index3] = mean(ellenbergF[notZero], na.rm = TRUE)
    index2 = 1
    index3 = index3 + 1
    notZero = c()
}

pdf("EllenbergFMeanFix.pdf")
plot(abandonedNo, ellenbergFAverage, xlab = "Time since abandonment (years)", ylab =
"Mean (unweighted) Ellenberg F value per releve")
dev.off()

#EllenbergF Weighted Mean
notZero = c()
index2 = 1
index3 = 1
ellenbergFWeightAverage = c()
for (column in ellenbergData){
    for (value in column) {
        notZero[index2] = (value != 0)
        index2 = index2 + 1
    }
    ellenbergFWeightAverage[index3] = weighted.mean(ellenbergF[notZero], column[notZero],
na.rm = TRUE)
    index2 = 1
    index3 = index3 + 1
    notZero = c()
}

pdf("EllenbergFWeigthMean.pdf")
plot(abandonedNo, ellenbergFWeightAverage)
dev.off()

#Ellenberg N Mean of Means
#Separate mean values by site

groups = c(rep("AM", 5), rep("APC", 4), rep("APE", 4), rep("APW", 3), rep("BFC", 6),
rep("BFE", 5), rep("BFO", 3), rep("CN", 5), rep("CA", 10), rep("FN", 5), rep("FS", 5), rep("G-
O", 5), rep("GA", 3), rep("GN", 5), rep("GSI", 6), rep("GS", 5), rep("H-ST.IE", 3), rep("H-
```

```
ST.IW", 5), rep("L-C", 10), rep("L-CW", 3), rep("L-S", 6), rep("N-EB", 3), rep("ONE", 5),
rep("RD", 10), rep("ST.HA", 5), rep("ST.HCANN", 5), rep("ST.HCANS", 5), rep("ST.HL", 4),
rep("SN", 5), rep("SS", 5), rep("TE", 3), rep("TW", 5), rep("WQ", 3), rep("WC", 5), rep("WCJ",
5))
EllenbergNFrame = data.frame(group = groups,
		lengthOfAbandonment = abandonedNo,
		EllenbergNMean = ellenbergNAverage )

#Find mean of means and plot
siteNAverage = aggregate(EllenbergNFrame$EllenbergNMean, list(EllenbergNFrame$group,
EllenbergNFrame$lengthOfAbandonment), mean)

pdf("sitesEllenbergNMeanFix.pdf")
plot(siteNAverage$Group.2, siteNAverage$x, xlab = "Time since abandonment (years)", ylab
= "Mean (unweighted) Ellenberg N values per releve per site")
dev.off()

#Ellenberg N Mean of Weighted Means
#Separate mean values by site

EllenbergNWeightFrame = data.frame(group = groups,
		lengthOfAbandonment = abandonedNo,
		EllenbergNWeightMean = ellenbergNWeightAverage )

#Find mean of means and plot
siteNWeightAverage = aggregate(EllenbergNWeightFrame$EllenbergNWeightMean,
list(EllenbergNWeightFrame$group, EllenbergNWeightFrame$lengthOfAbandonment), mean)

pdf("sitesEllenbergNWeightMean.pdf")
plot(siteNWeightAverage$Group.2, siteNWeightAverage$x)
dev.off()

#Ellenberg F Mean of Means
#Separate mean values by site

EllenbergFFrame = data.frame(group = groups,
		lengthOfAbandonment = abandonedNo,
		EllenbergFMean = ellenbergFAverage )

#Find mean of means and plot
siteFAverage = aggregate(EllenbergFFrame$EllenbergFMean, list(EllenbergFFrame$group,
EllenbergFFrame$lengthOfAbandonment), mean)

pdf("sitesEllenbergFMeanFix.pdf")
plot(siteFAverage$Group.2, siteFAverage$x, xlab = "Time since abandonment (years)", ylab
= "Mean (unweighted) Ellenberg F values per releve per site")
dev.off()

#Ellenberg F Mean of Weighted Means
#Separate mean values by site

EllenbergFWeightFrame = data.frame(group = groups,
		lengthOfAbandonment = abandonedNo,
		EllenbergFWeightMean = ellenbergFWeightAverage )

#Find mean of means and plot
siteFWeightAverage = aggregate(EllenbergFWeightFrame$EllenbergFWeightMean,
list(EllenbergFWeightFrame$group, EllenbergFWeightFrame$lengthOfAbandonment), mean)

pdf("sitesEllenbergFWeightMean.pdf")
```

```
plot(siteFWeightAverage$Group.2, siteFWeightAverage$x)
dev.off()

#Cluster analysis of vegetative data from railways

#07/07/14

#Robert Ashton

setwd("C:\\RFiles\\RailTrack\\Cluster\\")
railData = read.csv(file = "ImportData.csv", stringsAsFactors = FALSE, header = TRUE, sep =
",", row.names = 1)
names(railData)
str(railData)
#Convert to matrix for use in metaMDS
mdsData = data.matrix(railData)
str(mdsData)
names(mdsData)

colUse = as.factor(gsub("\\d", "", row.names(railData)))
colCodes = c("#000000", "#FFFF00", "#1CE6FF", "#FF34FF", "#FF4A46", "#008941",
"#006FA6", "#A30059", "#FFDBE5", "#7A4900", "#0000A6", "#63FFAC", "#B79762",
"#004D43", "#8FB0FF", "#997D87", "#5A0007", "#809693", "#FF0800", "#1B4400",
"#4FC601", "#3B5DFF", "#4A3B53", "#FF2F80", "#61615A", "#BA0900", "#6B7900",
"#00C2A0", "#FFAA92", "#FF90C9", "#B903AA", "#D16100", "#DDEFFF", "#000035",
"#7B4F4B")
colCodes2 = rainbow(35)
colVec = colCodes[colUse]

###06/04/14###

###Heierachical Cluser Analysis###

library(labdsv)
library(ape)

distData = dsvdis(mdsData, "steinhaus")

clustAnal = hclust(distData, "ward.D", members = NULL)
clustPhy = as.phylo(clustAnal)

pdf("clusterPlotNew.pdf", width = 20, height = 7)
par(mar = c(0,0,3,0))
plot(clustPhy, cex = 0.5, tip.color = colVec, direction = "downwards", main = "Hierachical
Clustering using Steinhaus Coeff and Ward Clustering Method                07/04/14")
dev.off()

clustAnalD = as.dendrogram(clustAnal)

clusMember = cutree(clustAnal, 35)

colLab <- function(n) {
  if (is.leaf(n)) {
    a <- attributes(n)
    labCol <- colCodes[clusMember[which(names(clusMember) == a$label)]]
    attr(n, "nodePar") <- c(a$nodePar, lab.col = labCol, cexlab = 0.5, pch = NA)
  }
  n
}
```

```
clusDendro = dendrapply(clustAnalD, colLab)

plot(clusDendro, leaflab = 0.5)

###15/08/14###

#Indicator Species Analyis

#Remove empty species
mdsDataRM = mdsData[ , -which(colnames(mdsData) %in% c("Bryum.caespiticium"))]

cut2 = cutree(clustAnal, k = 2)
indValue2 = indval(mdsDataRM, cut2)

cut7 = cutree(clustAnal, k = 7)
indValue7 = indval(mdsDataRM, cut7)

###TRY INDICSPECIES PACKAGE###

library(indicspecies)

cut7 = cutree(clustAnal, k = 7)
indValueMulti7 = multipatt(data.frame(mdsDataRM), cut7, control = how(nperm=999))

indValueMulti2 = multipatt(data.frame(mdsDataRM), cut2, control = how(nperm = 999))

cut4 = cutree(clustAnal, k = 4)
indValue4 = indval(mdsDataRM, cut4)

###16/08/14###

dendro = as.dendrogram(clustAnal)

plot(dendro)

plot(cut(dendro, h = 2.75)$upper, main = "Upper tree of cut at h=2.75")

par(cex = 1, mar = c(5,8,4,1))
plotting  = plot(cut(dendro, h = 4)$upper, main = "", leaflab = "textlike")
labels(plotting, label = c("a","b"))
par(cex = 1)
title(main = "Hierachical Clustering Using Steinhaus Coeff and Ward Clustering Method
07/04/14")
axis(2)

###Try new approach with dendextend package###

library(dendextend)

dendro = as.dendrogram(clustAnal)

top2Clusts = cut(dendro, h = 4)$upper

y = data.frame(c("Senecio.jacobaea", 0.686, 0.001, "***"),
c("Dactylis.glomerata", 0.591, 0.002, "**"),
c("Vulpia.bromoides", 0.534, 0.001, "***"))
spec1 = c("Senecio.jacobaea", "Dactylis.glomerata", "Vulpia.bromoides")
stat1 = c(0.686, 0.591, 0.534)
pVal1 = c(0.001, 0.002, 0.001)
star1 = c("***", "**", "***")
```

```
clust1DF = data.frame(spec1, stat1, pVal1, star1)

labels(top2Clusts) = list(clust1DF, "Cluster 2")
labels_colors(top2Clusts) = c(2, 3)

par(mar = c(5,8,4,1))
plot(top2Clusts, leaflab = "t", main = "Hierachical Clustering Using Steinhaus Coeff and Ward
Clustering Method With Two Clusters            07/04/14")

#####Simplified version#####

##Practice##
library(dendextend)

dendro = as.dendrogram(clustAnal)
top2Clusts = cut(dendro, h = 4)$upper
top2Clusts = hang.dendrogram(top2Clusts, hang = -1)
labels(top2Clusts) = c("A", "B")


plot(top2Clusts, axes = FALSE, edgePar = list(p.lty = 0, p.lwd = 20))

##PLOT FOR 7 CLUSTERS##
top7Clusts = cut(dendro, h = 2.75)$upper
top7Clusts = hang.dendrogram(top7Clusts, hang = -1)
labels(top7Clusts) = c("A - 19", "B - 14", "C - 40", "D - 10", "E - 14", "F - 11", "G- 66")

pdf("clusterPlot7Clusters.pdf", width = 10)
plot(top7Clusts, axes = FALSE, center = TRUE)
dev.off()

### 18/09/14 ###

##Code to take 7 clusters and calculate mean time and st dev
##for the clusters and see if there is a sig difference
##using ANOVA for unequal sample sizes

abandonTime = read.csv(file = "yearabandonmentImport.csv", header = FALSE, sep = ",")

abandonTime = as.numeric(abandonTime)

clustAband = data.frame(cut7, abandonTime)
meanAbandonByClust = tapply(clustAband$abandonTime, clustAband$cut7, FUN = mean)
sdAbandonByClust = tapply(clustAband$abandonTime, clustAband$cut7, FUN = sd)

write.csv(meanAbandonByClust, file = "MeanTimeSinceAbandonmentByCluster.csv")
write.csv(sdAbandonByClust, file = "SDTimeSinceAbandonmentByCluster.csv")

fm1 = aov(abandonTime~cut7, data = clustAband)
anovaOfAbandonByClust = anova(fm1)

###04/10//14###

##Code to calculate fidelity, exclusivity, mean cover % within
##clusters and mean % cover outside of clusters.

#Identify species which need to be plotted
indValData = read.csv(file = "indValueImport.csv", stringsAsFactors = FALSE, header =
TRUE, sep = ",", row.names = 1)
names(indValData)
```

```
str(indValData)

allIndicatorSpecies = rownames(indValData)

reducedDF = data.frame(mdsData[, allIndicatorSpecies])

#Need to add a column for the clusters the sites belong to
reducedDFCluster = data.frame(cut7, reducedDF)

#Use code from previous calculations of presence for calculating
#fidelity and exclusivity

relevesPresentIn = function(columnVector) {
	totalRelevesPresentIn = 0
	for (value in columnVector) {
	   if (value != 0) {
	      totalRelevesPresentIn = totalRelevesPresentIn + 1
	   }
	}
	return(totalRelevesPresentIn)
}

setToNA = function(columnVector) {
	columnVector[columnVector[] == 0 ] = NA
	return(columnVector)
}

fid.ex.Appearance = aggregate(reducedDFCluster, by = list(cut7),
FUN = relevesPresentIn)
fid.ex.Tot = aggregate(reducedDFCluster, by = list(cut7), FUN = sum)

te = as.factor(indValData[,1])
levels(te) = c(3,5,4,6,7,2,1)
indValData[ , 1] = te
indValData[ ,2] = as.numeric(indValData[,2])

#Create list of names belonging to each cluster

specIn1 = rownames(indValData)[indValData[ ,1] == 1]
specIn2 = rownames(indValData)[indValData[ ,1] == 2]
specIn3 = rownames(indValData)[indValData[ ,1] == 3]
specIn4 = rownames(indValData)[indValData[ ,1] == 4]
specIn5 = rownames(indValData)[indValData[ ,1] == 5]
specIn6 = rownames(indValData)[indValData[ ,1] == 6]
specIn7 = rownames(indValData)[indValData[ ,1] == 7]

clust1App = fid.ex.Appearance[specIn1]
clust1Tot = fid.ex.Tot[specIn1]
clust2App = fid.ex.Appearance[specIn2]
clust2Tot = fid.ex.Tot[specIn2]
clust3App = fid.ex.Appearance[specIn3]
clust3Tot = fid.ex.Tot[specIn3]
clust4App = fid.ex.Appearance[specIn4]
clust4Tot = fid.ex.Tot[specIn4]
clust5App = fid.ex.Appearance[specIn5]
clust5Tot = fid.ex.Tot[specIn5]
clust6App = fid.ex.Appearance[specIn6]
clust6Tot = fid.ex.Tot[specIn6]
clust7App = fid.ex.Appearance[specIn7]
clust7Tot = fid.ex.Tot[specIn7]
```

```
clust1.A = data.frame(as.numeric(clust1App[1,]), colSums(clust1App[2:7,]))
names(clust1.A) = c("native", "other")
clust1.T = data.frame(as.numeric(clust1Tot[1,]), colSums(clust1Tot[2:7,]))
names(clust1.T) = c("native", "other")

clust2.A = data.frame(as.numeric(clust2App[2,]), colSums(clust2App[c(1,3:7),]))
names(clust2.A) = c("native", "other")
clust2.T = data.frame(as.numeric(clust2Tot[2,]), colSums(clust2Tot[c(1,3:7),]))
names(clust2.T) = c("native", "other")

clust3.A = data.frame(as.numeric(clust3App[3,]), colSums(clust3App[c(1:2,4:7),]))
names(clust3.A) = c("native", "other")
clust3.T = data.frame(as.numeric(clust3Tot[3,]), colSums(clust3Tot[c(1:2,4:7),]))
names(clust3.T) = c("native", "other")

clust4.A = data.frame(as.numeric(clust4App[4,]), colSums(clust4App[c(1:3,5:7),]))
names(clust4.A) = c("native", "other")
clust4.T = data.frame(as.numeric(clust4Tot[4,]), colSums(clust4Tot[c(1:3,5:7),]))
names(clust4.T) = c("native", "other")

clust5.A = data.frame(as.numeric(clust5App[5,]), colSums(clust5App[c(1:4,6:7),]))
names(clust5.A) = c("native", "other")
clust5.T = data.frame(as.numeric(clust5Tot[5,]), colSums(clust5Tot[c(1:4,6:7),]))
names(clust5.T) = c("native", "other")

clust6.A = data.frame(as.numeric(clust6App[6,]), colSums(clust6App[c(1:5,7),]))
names(clust6.A) = c("native", "other")
clust6.T = data.frame(as.numeric(clust6Tot[6,]), colSums(clust6Tot[c(1:5,7),]))
names(clust6.T) = c("native", "other")

clust7.A = data.frame(as.numeric(clust7App[7,]), colSums(clust7App[1:6,]))
names(clust7.A) = c("native", "other")
clust7.T = data.frame(as.numeric(clust7Tot[7,]), colSums(clust7Tot[1:6,]))
names(clust7.T) = c("native", "other")

meanPercent1 = clust1.T/clust1.A
meanPercent2 = clust2.T/clust2.A
meanPercent3 = clust3.T/clust3.A
meanPercent4 = clust4.T/clust4.A
meanPercent5 = clust5.T/clust5.A
meanPercent6 = clust6.T/clust6.A
meanPercent7 = clust7.T/clust7.A

write.csv(meanPercent1 , "meanPercentCover1.csv")
write.csv(meanPercent2 , "meanPercentCover2.csv")
write.csv(meanPercent3 , "meanPercentCover3.csv")
write.csv(meanPercent4 , "meanPercentCover4.csv")
write.csv(meanPercent5 , "meanPercentCover5.csv")
write.csv(meanPercent6 , "meanPercentCover6.csv")
write.csv(meanPercent7 , "meanPercentCover7.csv")

write.csv(clust1.A, "AppearancesClust1.csv")
write.csv(clust2.A, "AppearancesClust2.csv")
write.csv(clust3.A, "AppearancesClust3.csv")
write.csv(clust4.A, "AppearancesClust4.csv")
write.csv(clust5.A, "AppearancesClust5.csv")
write.csv(clust6.A, "AppearancesClust6.csv")
write.csv(clust7.A, "AppearancesClust7.csv")

##Plotting of richness against time since abandonment###
```

```
##18/08/14##

#Robert Ashton#

setwd("C:\\RFiles\\RailTrack\\Richnes & Diversity\\")
railData = read.csv(file = "ImportData.csv", stringsAsFactors = FALSE, header = TRUE, sep =
",", row.names = 1)
names(railData)
str(railData)
#Convert to matrix for easy use
dataMatrix = data.matrix(railData)
str(dataMatrix)
names(dataMatrix)

#Import year since abandondment data
sinceAbandon = read.csv(file = "yearAbandonmentImport.csv", header = FALSE)
sinceAbandon = as.numeric(sinceAbandon)

totalNonZero = function(Row){
    nonZero = 0
    for (value in Row){
       if (value == 0){
       }
       else {
           nonZero = nonZero + 1
       }
    }
    return(nonZero)
}

richness = apply(dataMatrix, MARGIN = 1, FUN = totalNonZero)

pdf("abandonedTimeVRichness.pdf")
plot(sinceAbandon, richness)
dev.off()

groups = c(rep("AM", 5), rep("APC", 4), rep("APE", 4), rep("APW", 3), rep("BFC", 6),
rep("BFE", 5), rep("BFO", 3), rep("CN", 5), rep("CA", 10), rep("FN", 5), rep("FS", 5), rep("G-
O", 5), rep("GA", 3), rep("GN", 5), rep("GSI", 6), rep("GS", 5), rep("H-ST.IE", 3), rep("H-
ST.IW", 5), rep("L-C", 10), rep("L-CW", 3), rep("L-S", 6), rep("N-EB", 3), rep("ONE", 5),
rep("RD", 10), rep("ST.HA", 5), rep("ST.HCANN", 5), rep("ST.HCANS", 5), rep("ST.HL", 4),
rep("SN", 5), rep("SS", 5), rep("TE", 3), rep("TW", 5), rep("WQ", 3), rep("WC", 5), rep("WCJ",
5))

RichnessFrame = data.frame(group = groups,
             lengthOfAbandonment = sinceAbandon,
             rich = richness )

siteRichnessMean = aggregate(RichnessFrame$rich, list(RichnessFrame$group,
RichnessFrame$lengthOfAbandonment), mean)

pdf("abandonedTimeVRichnessMEANOFSITESfix.pdf")
plot(siteRichnessMean$Group.2, siteRichnessMean$x, xlab = "Time since abandonment
(years)", ylab = "Mean richness per site")
dev.off()


##Diversity##

library(vegan)
```

```
divData = diversity(dataMatrix, index = "shannon", MARGIN = 1, base = exp(1))

pdf("abandonedTimeVDiversity.pdf")
plot(sinceAbandon, divData)
dev.off()

diversityFrame = data.frame(group = groups,
                lengthOfAbandonment = sinceAbandon,
                div = divData )

siteDiversityMean = aggregate(diversityFrame$div, list(diversityFrame$group,
diversityFrame$lengthOfAbandonment), mean)

pdf("abandonedTimeVDiversityMEANOFSITESfix.pdf")
plot(siteDiversityMean$Group.2, siteDiversityMean$x, xlab = "Time since abandonment
(years)", ylab = "Mean diversity per site")
dev.off()

### 18/09/14 ###

## Robert Ashton #

## Code to find how abundent a species is and then write
## this to a csv file, also write to csv all species which
## are only present in one releve. Also writes as a csv all
## species which are present in 20 or more releves.

setwd("C:\\RFiles\\RailTrack\\Presence\\")
railData = read.csv(file = "presenceData.csv", stringsAsFactors = FALSE, header = TRUE,
sep = ",", row.names = 1)
names(railData)
str(railData)
#Convert to matrix for use in metaMDS
mdsData = data.matrix(railData)
str(mdsData)
names(mdsData)

##function to calculate how many releves present in

relevesPresentIn = function(columnVector) {
      totalRelevesPresentIn = 0
      for (value in columnVector) {
         if (value != 0) {
            totalRelevesPresentIn = totalRelevesPresentIn + 1
         }
      }
      return(totalRelevesPresentIn)
}

presenceFrame = apply(mdsData, 2, FUN = relevesPresentIn)

write.csv(presenceFrame, file = "presenceFrame.csv")

removeAllButValueOne = function(aVector) {
     index = 1
     removeVector = c()
     for (value in aVector) {
       if (value != 1) {
         removeVector = c(-index, removeVector)
```

```
        }
          index = index + 1
      }
      return(aVector[removeVector])
}

onlyOne = removeAllButValueOne(presenceFrame)

write.csv(onlyOne, file = "onlyOnePresent.csv")

removeAllLessThan20 = function(aVector) {
      index = 1
      removeVector = c()
      for (value in aVector) {
        if (value < 20) {
          removeVector = c(-index, removeVector)
        }
          index = index + 1
      }
      return(aVector[removeVector])
}

moreThan20 = removeAllLessThan20(presenceFrame)

write.csv(moreThan20, file = "moreThan20Present.csv")

###04/10/14###

##We are also interested in the mean percent cover of
##each species in a releve. Write code to find this

#Need to loop over each species like above but sum the values.

#Easy mode
setToNA = function(columnVector) {
       columnVector[columnVector[] == 0 ] = NA
       return(columnVector)
}

mdsNA = apply(mdsData, 2 , FUN = setToNA)
means = apply(mdsNA, 2, FUN = mean, na.rm = TRUE)
sds = apply(mdsNA, 2, FUN = sd, na.rm = TRUE)

greater20DF = data.frame(moreThan20, round(means[names(moreThan20)]),
round(sds[names(moreThan20)]))

write.csv(greater20DF, "greater20Frame.csv")

###21/09/14###

##Robert Ashton##

#Canonical Correspondence Analysis#

setwd("C:\\RFiles\\RailTrack\\Environmental\\")
railData = read.csv(file = "CCAImport.csv", stringsAsFactors = FALSE, header = TRUE, sep =
",", row.names = 1)
names(railData)
str(railData)
#Convert to matrix for easy use
```

```
dataMatrix = data.matrix(railData)
str(dataMatrix)
names(dataMatrix)

#Separate Matrices
speciesMatrix = dataMatrix[ , 1:246]
envMatrix = dataMatrix[ , 247:261]

#Need to standardise the env matrix.

## 23/09/14 ##

library(vegan)

standEnv = decostand(envMatrix, method = "range", MARGIN = 2, na.rm = TRUE)

# Perform CCA

spe.cca1 =  cca(speciesMatrix, standEnv[ , 1:5] , na.action = na.omit)
pdf("CCA_with_Alt,Asp,Yr,Rain,SumTem.pdf")
plot(spe.cca1, display = c("sites", "bp"), type = "text")
dev.off()

#remove NA rows
noNAData = na.omit(dataMatrix)
speciesNoNA = noNAData[ , 1:246]
envMatrixNoNA = noNAData[ , 247:261]
spe.cca2 = cca(speciesNoNA, envMatrixNoNA[ , 6:15], na.action = na.omit)
pdf("CCA_with_pH,Mois,Org,Mg,Pb,K,Ca,Cu,Cd,Ni.pdf")
plot(spe.cca2, display = c("sites", "bp"), type = "text")
dev.off()

spe.cca3 = cca(speciesNoNA, envMatrixNoNA, na.action = na.omit)
pdf("CCA_with_All.pdf")
plot(spe.cca3, display = c("sites", "bp"), type = "text")
dev.off()

# Test with just SummerTemp, Rainfall
spe.cca4 = cca(speciesMatrix, standEnv[ ,4:5], na.action = na.omit)
pdf("CCA_with_SumTemp,Rainfall.pdf")
plot(spe.cca4, display = c("sites", "bp"), type = "text")
dev.off()

# Plot with SummerTemp, Rainfall and PH
#find no NA for PH
noPHNA = na.omit(dataMatrix[ , 1:252])
speciesNoPHNA = noPHNA[ ,1:246]
envMatrixNoPHNA = noPHNA[ ,247:252]

spe.cca5 = cca(speciesNoPHNA, envMatrixNoPHNA[,4:6], na.action = na.omit)
pdf("CCA_with_SumTemp,Rainfall,pH.pdf")
plot(spe.cca5, display = c("sites", "bp"), type = "text")
dev.off()

###24/09/14###

##Plot with site scaling##

plot(spe.cca1, scaling = 1, display = c("sites", "bp"), type = "text")       # Same as above,
suggests done by default
```

```
#Use cut from wards clustering method#

library(labdsv)
distData = dsvdis(speciesMatrix, "steinhaus")
clustAnal = hclust(distData, "ward.D", members = NULL)
cut7 = cutree(clustAnal, k = 7)

#Identify species which need to be plotted
indSpec1 = c("Festuca.rubra")
indSpec2 = c("Schistidium.crassipilum", "Urtica.dioica", "Cardamine.flexuosa",
"Schistidium.apocarpum", "Barbula.convoluta" ,"Epilobium.montanum")
indSpec3 = c("Epilobium.ciliatum", "Geranium.robertianum", "Fraxinus.excelsior")
indSpec4 = c("Arrhenatherum.elatius")
indSpec5 = c("Eupatorium.cannabinum", "Agrostis.stolonifera")
indSpec6 = c("Vulpia.bromoides", "Galium.aparine", "Anthriscus.sylvestris",
"Pimpinella.saxifraga" ,"Veronica.arvensis", "Picris.echioides", "Sonchus.asper")
indSpec7 = c("Linaria.vulgaris", "Deschampsia.cespitosa", "Tanacetum.vulgare",
"Bryum.argenteum", "Betula.pendula", "Agrostis.capillaris")

indSpec = c(indSpec1, indSpec2, indSpec3, indSpec4, indSpec5, indSpec6, indSpec7)

indSpecLab1 = c("Fe.rub.")
indSpecLab2 = c("Sc.cras.", "Ur.dio.", "Ca.flex.", "Sc.apoc.", "Ba.con.", "Ep.mont.")
indSpecLab3 = c("Ep.cil.", "Ge.rob.", "Fr.exce.")
indSpecLab4 = c("Ar.elat.")
indSpecLab5 = c("Eu.can.", "Ag.stol.")
indSpecLab6 = c("Vu.bro.", "Ga.apar.", "An.syl.", "Pi.sax.", "Ve.arv.", "Pi.ech.", "So.asp.")
indSpecLab7 = c("Li.vul.", "De.ces.", "Ta.vul.", "Br.arg.", "Be.pen.", "Ag.cap.")

indSpecLab = c(indSpecLab1, indSpecLab2, indSpecLab3, indSpecLab4, indSpecLab5,
indSpecLab6, indSpecLab7)

indSpecClust = c(1, rep(2, 6), rep(3, 3), 4, rep(5, 2), rep(6, 7), rep(7, 6))

#set colours for legened and points
leg.text = c("A", "B", "C", "D", "E", "F", "G")
leg.col = c("#49FF00FF", "#0092FFFF", "#FF8000FF", "#4900FFFF", "#222A0AFF",
"#FFDB00FF", "#FF0000FF")
colUse = c("#FF0000FF", "#FFDB00FF", "#49FF00FF", "#FF8000FF", "#0092FFFF",
"#4900FFFF", "#222A0AFF")[cut7]

#For Alt, Asp, Year, Rainfall, and Summer Temp
pdf("CCA_Coloured_with_A,A,Y,R,S_ColFix.pdf")
plot(spe.cca1, scaling = 1, type = "none", xlim = c(-5.5,5), ylim = c(-4,4))
points(spe.cca1, display = "sites", col = colUse)
text(spe.cca1, display = "species", select = indSpec, labels = indSpecLab, col =
rainbow(7)[indSpecClust], pch = 3)
points(spe.cca1, display = "bp")
text(spe.cca1, display = "bp")
legend("topleft", legend = leg.text, fill = leg.col)
dev.off()

#For pH, moisture, organic content, Mg, Pb, K, Ca, Cu, Cd, Ni
pdf("CCA_Coloured_with_ph,M,O,Mg,Pb,K,Ca,Cu,Cd,Ni_ColFix.pdf")
plot(spe.cca2, scaling = 1, type = "none", xlim = c(-3, 2), ylim = c(-2, 2))
points(spe.cca2, display = "sites", col = colUse)
points(spe.cca2, display = "species", select = indSpec, col = rainbow(7)[indSpecClust], pch =
3)
points(spe.cca2, display = "bp")
```

```
text(spe.cca2, display = "bp")
legend("bottomleft", legend = leg.text, fill = leg.col)
dev.off()

#For all environmental variables
pdf("CCA_Coloured_with_all_ColFix.pdf")
plot(spe.cca3, scaling = 1, type = "none", xlim = c(-4.5, 4), ylim = c(-1.5, 4))
points(spe.cca3, display = "sites", col = colUse)
points(spe.cca3, display = "species", select = indSpec, col = rainbow(7)[indSpecClust], pch =
3)
points(spe.cca3, display = "bp")
text(spe.cca3, display = "bp")
legend("topright", legend = leg.text, fill = leg.col)
dev.off()

###03/10/14###
##We want to label the corsses in the above diagrams instead
##with the species names. To do this we convert to a data frame
##and use the setnames function in the data.table package and
##then convert back to a matrix and complete the plotting again.

library(data.table)
tempDF = data.frame(dataMatrix)
setnames(tempDF, indSpec, indSpecLab)
dataMatrixLab = data.matrix(tempDF)
speciesMatrixLab = dataMatrixLab[ , 1:246]
envMatrixLab = dataMatrixLab[ , 247:261]
standEnvLab = decostand(envMatrixLab, method = "range", MARGIN = 2, na.rm = TRUE)

spe.cca1Lab =  cca(speciesMatrixLab, standEnvLab[ , 1:5] , na.action = na.omit)
noNADataLab = na.omit(dataMatrixLab)
speciesNoNALab = noNADataLab[ , 1:246]
envMatrixNoNALab = noNADataLab[ , 247:261]
spe.cca2Lab = cca(speciesNoNALab, envMatrixNoNALab[ , 6:15], na.action = na.omit)
spe.cca3Lab = cca(speciesNoNALab, envMatrixNoNALab, na.action = na.omit)

#For Alt, Asp, Year, Rainfall, and Summer Temp
pdf("CCA_Coloured_with_A,A,Y,R,S_ColFix.pdf")
plot(spe.cca1Lab, scaling = 1, type = "none", xlim = c(-5.5,5), ylim = c(-4,4))
points(spe.cca1Lab, display = "sites", col = colUse)
text(spe.cca1Lab, display = "species", select = indSpecLab, col = rainbow(7)[indSpecClust],
pch = 3)
points(spe.cca1Lab, display = "bp")
text(spe.cca1Lab, display = "bp")
legend("topleft", legend = leg.text, fill = leg.col)
dev.off()

#For pH, moisture, organic content, Mg, Pb, K, Ca, Cu, Cd, Ni
pdf("CCA_Coloured_with_ph,M,O,Mg,Pb,K,Ca,Cu,Cd,Ni_ColFix.pdf")
plot(spe.cca2Lab, scaling = 1, type = "none", xlim = c(-3, 2), ylim = c(-2, 2))
points(spe.cca2Lab, display = "sites", col = colUse)
text(spe.cca2Lab, display = "species", select = indSpecLab, col = rainbow(7)[indSpecClust],
pch = 3)
points(spe.cca2Lab, display = "bp")
text(spe.cca2Lab, display = "bp")
legend("bottomleft", legend = leg.text, fill = leg.col)
dev.off()

#For all environmental variables
pdf("CCA_Coloured_with_all_ColFix.pdf")
```

```
plot(spe.cca3Lab, scaling = 1, type = "none", xlim = c(-4.5, 4), ylim = c(-1.5, 4))
points(spe.cca3Lab, display = "sites", col = colUse)
text(spe.cca3Lab, display = "species", select = indSpecLab, col = rainbow(7)[indSpecClust],
pch = 3)
points(spe.cca3Lab, display = "bp")
text(spe.cca3Lab, display = "bp")
legend("topright", legend = leg.text, fill = leg.col)
dev.off()

#Significance testing
anova(spe.cca1, step = 1000)

###01/10/14###
spe.cca1.1 = cca(speciesMatrix ~ Altitude + Aspect + YearSinceClose + Rainfall +
SummerTemp, data = data.frame(standEnv), na.action = na.omit)
anova(spe.cca1.1, by = "terms", perm = 1000)

spe.cca2.2 = cca(speciesMatrix ~ pH + Moisture + Organic + Mg + Pb + K + Ca + Cu + Cd +
Ni, data = data.frame(standEnv), na.action = na.omit)
m1 = update(spe.cca2.2, subset = -spe.cca2.2$na.action)
anova(m1, by = "terms", perm = 1000)

spe.cca3.3 = cca(speciesMatrix ~ ., data = data.frame(standEnv), na.action = na.omit)
m2 <- update(spe.cca3.3, subset = -spe.cca3.3$na.action)
anova(m2, by = "terms", perm = 1000)

###01/10/14###

##Calculate mean and SD of environmental variables for each
##cluster

envCluster = data.frame(as.factor(cut7), envMatrix)
colnames(envCluster)[1] = "cut7"
meanByClust = aggregate(envCluster[,-1], by = list(envCluster$cut7), FUN = mean, na.rm =
TRUE)
sdByClust = aggregate(envCluster[,-1], by = list(envCluster$cut7), FUN = sd, na.rm = TRUE)
write.csv(meanByClust, file = "meanByCluster.csv")
write.csv(sdByClust, file = "sdByCluster.csv")

##WWrong code left in for reference##
#aov.out = aov(cut7 ~
Altitude+Aspect+YearSinceClose+Rainfall+SummerTemp+pH*+Moisture+Organic+Mg+Pb+K
+Ca+Cu+Cd+Ni, data = envCluster, na.action = na.exclude)
#posthoc = TukeyHSD(x = aov.out, "Altitude", conf.level = 0.95)

#aov.out2 = aov(cut7 ~ as.factor(Altitude), data = envCluster)
#posthoc2 = TukeyHSD(x = aov.out2, "cut7")

###02/10/14###
#Try as written down
aAlt = aov(envCluster$Altitude ~ envCluster$cut7)
posthocAlt = TukeyHSD(x = aAlt, "envCluster$cut7")

aAsp = aov(envCluster$Aspect ~ envCluster$cut7)
posthocAsp = TukeyHSD(x = aAsp, "envCluster$cut7")

aYr = aov(envCluster$YearSinceClose ~ envCluster$cut7)
posthocYr = TukeyHSD(x = aYr, "envCluster$cut7")

aRai = aov(envCluster$Rainfall ~ envCluster$cut7)
```

```
posthocRai = TukeyHSD(x = aRai, "envCluster$cut7")

aTmp = aov(envCluster$SummerTemp ~ envCluster$cut7)
posthocTmp = TukeyHSD(x = aTmp, "envCluster$cut7")

apH = aov(envCluster$pH ~ envCluster$cut7)
posthocpH = TukeyHSD(x = apH, "envCluster$cut7")

aMoi = aov(envCluster$Moisture ~ envCluster$cut7)
posthocMoi = TukeyHSD(x = aMoi, "envCluster$cut7")

aOrg = aov(envCluster$Organic ~ envCluster$cut7)
posthocOrg = TukeyHSD(x = aOrg, "envCluster$cut7")

aMg = aov(envCluster$Mg ~ envCluster$cut7)
posthocMg = TukeyHSD(x = aMg, "envCluster$cut7")

aPb = aov(envCluster$Pb ~ envCluster$cut7)
posthocPb = TukeyHSD(x = aPb, "envCluster$cut7")

aK = aov(envCluster$K ~ envCluster$cut7)
posthocK = TukeyHSD(x = aK, "envCluster$cut7")

aCa = aov(envCluster$Ca ~ envCluster$cut7)
posthocCa = TukeyHSD(x = aCa, "envCluster$cut7")

aCu = aov(envCluster$Cu ~ envCluster$cut7)
posthocCu = TukeyHSD(x = aCu, "envCluster$cut7")

aCd = aov(envCluster$Cd ~ envCluster$cut7)
posthocCd = TukeyHSD(x = aCd, "envCluster$cut7")

aNi = aov(envCluster$Ni ~ envCluster$cut7)
posthocNi = TukeyHSD(x = aNi, "envCluster$cut7")

##03/10/14##
#Using agricole package for Tukeys

library(agricolae)
hsdAlt = HSD.test(y = aAlt, trt = "envCluster$cut7")
hsdAsp = HSD.test(y = aAsp, trt = "envCluster$cut7")
hsdYr = HSD.test(y = aYr, trt = "envCluster$cut7")
hsdRai = HSD.test(y = aRai, trt = "envCluster$cut7")
hsdTmp = HSD.test(y = aTmp, trt = "envCluster$cut7")
hsdpH = HSD.test(y = apH, trt = "envCluster$cut7")
hsdMoi = HSD.test(y = aMoi, trt = "envCluster$cut7")
hsdOrg = HSD.test(y = aOrg, trt = "envCluster$cut7")
hsdMg = HSD.test(y = aMg, trt = "envCluster$cut7")
hsdPb = HSD.test(y = aPb, trt = "envCluster$cut7")
hsdK = HSD.test(y = aK, trt = "envCluster$cut7")
hsdCa = HSD.test(y = aCa, trt = "envCluster$cut7")
hsdCu = HSD.test(y = aCu, trt = "envCluster$cut7")
hsdCd = HSD.test(y = aCd, trt = "envCluster$cut7")
hsdNi = HSD.test(y = aNi, trt = "envCluster$cut7")
```

APPENDIX 3 – MAVIS ANALYSIS

Location	Twinspan	Mavis	Light	Wetness	pH	Fertility	C	S	R
Amwlch 1	1	0	6.3	5.6	5.9	5.2	2.85	2.39	2.64
Amwlch 2	2	1	6.4	5.4	5.5	4.7	2.79	2.86	2.55
Amwlch 3	3	2	6.6	5.4	5.7	4.9	2.93	2.6	2.6
Amwlch 4	4	3	6	5.2	5.6	4.9	2.89	2.68	2.43
Amwlch 5	5	4	5.9	5.2	5.7	4.8	2.84	2.68	2.76
Appleby Shaded 1	6	5	5.9	6	5.9	5.8	1.77	2.62	3.31
Appleby Shaded 2	7	6	6	5.9	6.2	6	2.17	2.17	3.42
Appleby Shaded 3	8	7	5.7	6.6	6.1	5.8	2	2.11	3.44
Appleby Shaded 4	9	8	6.1	6.4	5.9	5.8	2.36	2.14	3.21
Appleby 1	10	9	6.6	5.3	6.2	5.9	2.82	2.45	2.64
Appleby 2	11	10	7.1	5.3	5.9	5.2	2.77	2.46	2.92
Appleby 3	12	11	6.7	5.2	5.8	5.5	2.61	2.21	3.18
Appleby 4	13	12	7	5.4	6.1	5.7	2.37	2.42	3.11
Appleby Wet 1	14	13	6.4	7.4	6.1	5.8	2.47	1.76	3.18
Appleby Wet 2	15	14	6.3	6.6	6.2	6.2	2.5	1.75	3.31
Appleby Wet 3	16	15	6.6	6	6.1	5.7	2.09	2.09	3.32
Bleanau Ffest Cutt. 1	17	16	6.4	5.3	5.9	5.2	3.32	2.56	2.04
Bleanau Ffest Cutt. 2	18	17	6.6	5.3	6.1	5.2	3.41	2.26	2.22
Bleanau Ffest Cutt. 3	19	18	6.5	5.3	6	5.2	3.62	2.14	1.9
Bleanau Ffest Cutt. 4	20	19	6.1	5.4	6.2	5.3	3.56	2.13	1.69
Bleanau Ffest Cutt. 5	21	20	5.3	5.8	6.8	6	4.5	1.5	1.2
Bleanau Ffest Cutt. 6	22	21	6.9	6.3	5.2	4.6	3	2.08	2.75
Bleanau Ffest Embankment 1	23	22	7.1	5.7	5.6	5	3.42	2.58	2.08
Bleanau Ffest Embankment 2	24	23	6.8	4.9	5.3	4.6	2.56	3.19	2.19
Bleanau Ffest Embankment 3	25	24	6.9	5.3	5.8	5.2	2.85	2.85	2.23
Bleanau Ffest Embankment 4	26	25	6.7	5.1	5.2	4	2.5	3.23	2.05
Bleanau Ffest Embankment 5	27	26	6.8	5.8	5.9	5.3	3.15	2.54	2.38
Bleanau Ffest Open 1	28	27	6.5	6.2	5	4.2	3.32	2.45	1.95
Bleanau Ffest Open 2	29	28	6.7	6.3	4.9	4.1	3.29	2.42	2.04
Bleanau Ffest Open 3	30	29	6.6	6.4	5.2	4.3	3.3	2.52	2.04
Cambridge 1	31	30	7.3	4.8	6.4	5.1	2.75	2.15	2.77
Cambridge 2	32	31	7.3	4.8	6.1	5	2.92	2.22	2.73
Cambridge 3	33	32	7.3	4.7	6.5	5.4	3	2	2.87
Cambridge 4	34	33	7.3	4.9	6.4	5.4	3.12	2.07	2.73
Cambridge 5	35	34	7.3	5.1	6.3	5.1	3	2.14	2.82
Carrington 1	36	35	7.1	5.4	5.9	4.7	3.1	1.62	2.81
Carrington 2	37	36	7.2	6.2	5.3	4.5	3.33	2.13	2.53
Carrington 3	38	37	6.9	6.1	5.7	4.6	3.88	1.88	1.88
Carrington 4	39	38	6.5	5.8	5.6	4.9	3.25	2.5	2.04
Carrington 5	40	39	7.1	5.9	5.4	4.4	3.21	2.13	2.33
Carrington 6	41	40	7.3	5.9	6	5.3	3.44	2.06	2.28

Carrington 7	42	41	7	5.5	6.2	5.3	3.58	1.84	2.42
Carrington 8	43	42	6.6	5.8	6.2	5.8	3.88	1.41	2.06
Carrington 9	44	43	7.2	5.6	6	5.2	3.18	2.18	2.71
Carrington 10	45	44	7	5.9	6.4	5.8	3.95	1.8	2
Fleetwood North 1	46	45	7.2	4.8	6.6	4.8	2.53	2.26	2.91
Fleetwood North 2	47	46	7.3	5.2	6.4	4.6	2.87	2.71	2.42
Fleetwood North 3	48	47	7.2	5.3	6.6	4.7	2.83	2.48	2.48
Fleetwood North 4	49	48	6.7	5.4	6.2	4.6	2.59	2.86	2.52
Fleetwood North 5	50	49	7.1	5.4	6.3	4.7	2.68	2.64	2.5
Fleetwood South 1	51	50	7.2	5.2	6.8	5.7	3.25	2	2.58
Fleetwood South 2	52	51	6.4	5.3	6.8	6	3.56	2.13	2.13
Fleetwood South 3	53	52	6.5	5	6.6	6	3.6	2.1	2.2
Fleetwood South 4	54	53	6.8	5.1	6.4	5.9	3.19	2.38	2.56
Fleetwood South 5	55	54	6.1	5.4	6.7	6.3	3.33	2.53	2.13
Gobowen Oswestry 1	56	55	6.2	5.2	6	6	3.17	1.89	2.61
Gobowen Oswestry 2	57	56	6.4	5.1	6.3	6.1	3.05	1.95	2.58
Gobowen Oswestry 3	58	57	6.4	5	6.1	5.9	2.95	2	2.63
Gobowen Oswestry 4	59	58	6.5	5	6.1	5.7	2.96	2.09	2.74
Gobowen Oswestry 5	60	59	6.6	4.8	6.4	5.9	3.21	1.71	2.64
Golborne Ash 1	61	60	7	6.3	5.8	4.9	4.25	1.75	1.75
Golborne Ash 2	62	61	7	6	5.9	5	3.92	2.08	1.92
Golborne Ash 3	63	62	7.1	5.9	6.2	5.8	3.9	2.1	2.1
Golborne North 1	64	63	7	5.3	6.2	5.1	2.74	2.29	3.06
Golborne North 2	65	64	7.1	5.3	6	4.9	2.83	2.61	2.96
Golborne North 3	66	65	7.1	5.2	6	5.1	2.84	2.4	2.96
Golborne North 4	67	66	7	5.3	5.9	5.2	3.13	2.53	2.73
Golborne North 5	68	67	7.1	5.3	6	5.1	2.76	2.29	3.06
Golborne Sidings 1	69	68	7	5.1	6.2	5.6	2.67	1.83	3.33
Golborne Sidings 2	70	69	7.2	5	6.5	5.6	2.7	1.9	3.3
Golborne Sidings 3	71	70	7.2	5.1	6.6	6	3.53	2.16	2.47
Golborne Sidings 4	72	71	7	5.4	6.6	6.2	3.38	1.79	2.63
Golborne Sidings 5	73	72	7.1	5.4	6.3	5.6	3.38	2.28	2.63
Golborne Sidings 6	74	73	7.2	5	6.6	5.9	2.94	2	2.94
Golborne South 1	75	74	6.8	5.3	6.1	5.8	3.35	1.87	2.57
Golborne South 2	76	75	7	5.2	6.1	5.9	3.5	1.82	2.5
Golborne South 3	77	76	6.9	5.3	6.3	6	3.65	1.75	2.35
Golborne South 4	78	77	6.8	5.1	6.7	6.3	3.75	1.81	2.25
Golborne South 5	79	78	7	5.1	7	7.1	4	1.6	2
Histon St Ives East 1	80	79	6.8	5.1	6.7	5.9	2.09	2.07	3.5
Histon St Ives East 2	81	80	6.9	5.4	6.7	6.1	2.71	2.12	2.9
Histon St Ives East 3	82	81	7	4.7	6.7	5.6	3.05	2.16	2.67
Histon St Ives West 1	83	82	7.2	4.8	6.6	5.1	2.42	2.15	3.13
Histon St Ives West 2	84	83	6.9	4.6	6.5	4.7	2.3	2.29	3.23
Histon St Ives West 3	85	84	7.1	4.8	6.6	4.9	2.45	2.47	2.8
Histon St Ives West 4	86	85	7.1	4.5	6.7	4.4	2.58	2.17	3.08
Histon St Ives West 5	87	86	7.2	4.9	6.5	4.8	2.79	2.31	2.93
Leek Cauldon 1	88	87	6.7	5.5	5.8	5.2	3.14	2.71	2.2

Leek Cauldon 2	89	88	7.1	5.3	6.1	5.1	3.29	2.42	2.61
Leek Cauldon 3	90	89	6.8	5.3	6.4	6	3.32	2.12	2.56
Leek Cauldon 4	91	90	6.9	5.6	6.1	5.7	3.58	2.32	2.26
Leek Cauldon 5	92	91	7	5.5	6.2	5.5	3.39	2.17	2.44
Leek Cauldon 6	93	92	6.7	5.3	6.1	5.1	3.1	2.3	2.78
Leek Cauldon 7	94	93	6.8	5.5	5.9	5.1	3.38	2	2.26
Leek Cauldon 8	95	94	6.7	5.6	5.9	5.2	3.38	2.44	2.44
Leek Cauldon 9	96	95	6.6	5.5	6.1	5.4	2.91	2.65	2.63
Leek Cauldon 10	97	96	7	5	6.3	5.6	3.2	2.27	2.8
Leek Cauldon West 1	98	97	6.7	5.5	6.4	5.5	3.44	1.84	2.56
Leek Cauldon West 2	99	98	5.8	6.1	5.5	5.2	3.3	2.5	2.03
Leek Cauldon West 3	100	99	6.5	5.3	5.9	5.3	2.83	1.96	2.91
Leek Stoke 1	101	100	7.1	5.2	6.2	5.1	2.74	1.91	3.11
Leek Stoke 2	102	101	6.8	5.3	6.3	5.4	2.68	2.1	2.77
Leek Stoke 3	103	102	6.9	5.3	6.1	4.6	3.06	2.31	2.61
Leek Stoke 4	104	103	7	5.7	5.7	4.6	2.94	2.48	2.56
Leek Stoke 5	105	104	7.1	5.4	6.1	5.1	3.02	2.21	3.74
Leek Stoke 6	106	105	7	5.7	5.9	5	3.24	2.36	2.4
Newport Ebbw Vale 1	107	106	6.7	5.4	6.6	5.8	2.84	2.03	2.86
Newport Ebbw Vale 2	108	107	6.9	5.4	6.6	5.7	3.19	1.98	2.72
Newport Ebbw vale 3	109	108	5.7	5.3	6.5	5.9	3.4	2.15	1.95
Oswestry N Embankment 1	110	109	7	5.1	6.1	5	2.41	2.49	2.89
Oswestry N Embankment 2	111	110	6.7	5.1	6.6	5.7	3.11	2.18	2.46
Oswestry N Embankment 3	112	111	6.8	5	6.9	5.9	3.29	2.29	2.29
Oswestry N Embankment 4	113	112	6.9	5.4	6.6	5.8	3.44	2.56	2.11
Oswestry N Embankment 5	114	113	7.2	5.2	6.5	5.7	3.5	2.25	2.5
Runcorn Docks 1	115	114	7.2	5.1	6.3	5.1	2.39	2.17	2.95
Runcorn Docks 2	116	115	7.2	5	6.2	5	2.5	2.19	2.88
Runcorn Docks 3	117	116	7.1	4.7	6.5	5.2	2.44	2.24	2.93
Runcorn Docks 4	118	117	7.2	5	6.4	5.3	2.47	2.11	2.86
Runcorn Docks 5	119	118	7.2	4.9	6.3	5.3	2.55	2.19	2.87
Runcorn Docks 6	120	119	7.1	4.9	6.5	5.3	2.57	2.13	2.83
Runcorn Docks 7	121	120	7.1	5	6.4	5.2	2.42	2.27	2.85
Runcorn Docks 8	122	121	6.9	5.1	6.5	5.3	2.89	1.92	2.56
Runcorn Docks 9	123	122	7.2	4.6	6.5	5.3	2.3	2.15	2.95
Runcorn Docks 10	124	123	7.2	4.7	6.6	5.7	2.93	1.93	2.8
St Helens Acid 1	125	124	6.7	5	6.9	5.9	2.74	2.04	2.78
St Helens Acid 2	126	125	6.9	6.1	6.6	6.1	3.58	1.88	2.19
St Helens Acid 3	127	126	6.8	6	6.5	6.2	3.57	1.95	2.19
St Helens Acid 4	128	127	7	5.8	6.2	5.4	3.06	2.25	2.28
St Helens Acid 5	129	128	7.1	6.4	6.6	5.7	3.31	1.85	2.38
St Helens Canal North 1	130	129	7.2	5.3	6.3	4.8	2.31	2.36	2.73
St Helens Canal North 2	131	130	7	5.6	5.9	5	2.5	2.3	2.8
St Helens Canal North 3	132	131	6.9	5.6	6.1	5.1	2.62	2.28	2.68
St Helens Canal North 4	133	132	6.9	5.5	6.1	5.1	2.6	2.22	2.84
St Helens Canal North 5	134	133	7	5.4	6.3	5.4	2.89	2.17	2.83
St Helens Canal South 1	135	134	7	5.3	6.6	5.4	3.45	2.36	2

St Helens Canal South 2	136	135	7	5.8	6.6	6	3.31	2	2.69
St Helens Canal South 3	137	136	7	5.8	6.7	6.4	3.58	1.83	2.42
St Helens Canal South 4	138	137	7	5.4	6.1	5.1	3.18	2.18	2.36
St Helens Canal South 5	139	138	7	5.6	6.4	5.6	3.29	2	2.43
St Helens Link 1	140	139	6.9	5.9	6.4	5.8	3.22	1.97	2.54
St Helens Link 2	141	140	7	5.9	6.1	5.3	2.93	2.07	2.71
St Helens Link 3	142	141	6.9	5.7	6.4	5.4	2.67	2.09	2.83
St Helens Link 4	143	142	6.9	6.7	6.6	6.6	3.65	1.71	2.35
Staveley North 1	144	143	6.6	5.4	5.6	4.8	3.05	1.95	2.59
Staveley North 2	145	144	6.7	5.5	6.2	5.6	3.36	1.95	2.45
Staveley North 3	146	145	6.9	5.4	6.2	5	2.77	2.15	2.69
Staveley North 4	147	146	7.1	5.3	6.1	4.5	2.71	2.41	2.53
Staveley North 5	148	147	6.9	5.4	6.1	5.3	3.12	2.24	2.59
Staveley South 1	149	148	6.7	5.3	5.8	5.2	2.8	2.09	2.78
Staveley South 2	150	149	6.9	5.2	6.2	5.1	2.77	2.14	2.83
Staveley South 3	151	150	6.7	5.3	6	5.2	2.88	2.06	2.79
Staveley South 4	152	151	6.7	5.2	6	5.1	2.98	2.11	2.76
Staveley South 5	153	152	6.6	5.5	5.8	5	3.17	2.23	2.33
Trecwn East 1	154	153	6.3	5.5	5.9	5.4	3.08	2.42	2.63
Trecwn East 2	155	154	6.4	5.2	5.6	4.8	2.91	2.5	2.77
Trecwn East 3	156	155	6.4	5.6	5.8	4.9	2.95	2.32	3
Trecwn West 1	157	156	6.5	5.3	6.1	5.2	2.78	2.43	2.84
Trecwn West 2	158	157	6.3	5.5	6	5.6	3.28	2.2	2.64
Trecwn West 3	159	158	6.7	5.2	6.2	5	3.26	2.48	2.3
Trecwn West 4	160	159	6.6	5.3	6	5	2.92	2.51	2.56
Trecwn West 5	161	160	6.6	5.3	6	5.1	3.14	2.3	2.5
Wirksworth Quarry 1	162	161	6.7	5.8	6.1	5.3	2.4	2.21	3.21
Wirksworth Quarry 2	163	162	6.3	5.3	6.7	5.7	2.62	2.26	2.88
Wirksworth Quarry 3	164	163	6.7	4.9	6.8	5	2.6	1.98	3.09
Woodthorpe Colliery 1	165	165	7	5	7.1	6.1	2.67	1	3.33
Woodthorpe Colliery 2	166	166	6.8	5.3	6.6	5.9	3.46	2.08	2.54
Woodthorpe Colliery 3	167	167	6.9	5.3	6.7	6.3	3.47	1.87	2.53
Woodthorpe Colliery 4	168	168	6.9	5.3	6.5	6.4	3.6	2.2	2.4
Woodthorpe Colliery 5	169	169	6.8	5.6	6.8	6.1	3.71	1.79	2.29
Woodthorpe Junction 1	170	170	7.1	5	6.4	5.1	2.9	2.22	2.82
Woodthorpe Junction 2	171	171	7.1	5	6.6	5.4	3.04	2.06	2.73
Woodthorpe Junction 3	172	172	7.2	5	6.7	5.3	2.76	2.11	2.89
Woodthorpe Junction 4	173	173	7.2	5	6.3	5.2	2.84	2.19	2.84
Woodthorpe Junction 5	174	174	7.2	5	6.5	5.2	2.69	2.22	2.81

APPENDIX 4 – TWINSPAN ANALYSIS

```
*******       TWINSPAN for Windows 2.3       *******
* Following analysis log is described in more detail *
* in the user's guide, located in the following file:*
* C:\Program Files\WinTWINS\userguid.pdf
******************************************************
 TWINSPAN - Mark O.Hill & modified by C.J.F. ter Braak and H.J.B. Birks and Petr Smilauer

 Version 2.3- August 2005


 This version of TWINSPAN allows you to specify WEIGHTS for samples and species at the input device

 Number of cut levels:                    3

 Cut levels:
    0.00    2.00    5.00

 Reading data matrix from device 5
 WCanoImp produced data file

 Input data file :
 Title  : WCanoImp produced data file
 Format :  (I5,1X,24F3.0,11(/6X,(24F3.0)))

 Number of samples    174

 Number of species    273

 Length of raw data array      6674
      1    1000      6    1000      7    2000     17    5000     22    4000     42    1000
     47    1000     78    1000     80    3000     90    1000     92    2000    101    1000
    113    4000    118    4000    122    2000    142    1000    148    1000    174    2000
    181    2000    204    6000    217    1000    223    1000    234    1000    237    1000
     -1      6    5000     17    5000     22    2000     29    1000     47    1000     52
   1000     78    2000     93    1000    101    1000    113    1000    118    4000    122
   4000    142    1000    174    1000    204    5000    217    2000    223    1000    260
   1000     -1     17    6000     22    2000     29    4000     42    1000     52    1000
     78    4000    101    4000    113    1000    118    4000    122    4000    146    1000
    148    1000    174    2000    181    1000    204    4000    223    1000     -1      6
   ..................................................................................................
   4000    273    4000     -1      6    2000     22    2000     37    2000     45    1000
     47    1000     63    2000     78    2000     87    4000     91    1000     92    1000
     93    1000     96    1000    101    4000    121    1000    122    2000    125    1000
    137    1000    146    2000    175    2000    204    2000    230    1000    236    4000
    237    1000    255    4000    257    1000    273    4000     -1      6    1000     22
   1000     37    1000     38    1000     47    1000     63    1000     65    1000     78
   2000     80    1000     87    4000     90    1000     91    1000     92    1000     93
   1000     96    1000    101    2000    113    1000    121    2000    123    1000    137
   2000    142    1000    146    2000    175    1000    195    4000    204    4000    230
   1000    236    2000    237    1000    252    1000    255    4000    273    4000     -1

 SPECIES NAMES
```

1 Pter _aqu| 2 Acer _pse| 3 Achi _mil| 4 Agri _eup| 5 Agro _git| 6 Agro _cap| 7 Agro _sto| 8 Aira _car
9 Alli _pet| 10 Alnu _inc| 11 Alnu _glu| 12 Alop _pra| 13 Ambl _ser| 14 Anag _arv| 15 Ange _syl| 16 Anis _ste
17 Anth _odo| 18 Anth _syl| 19 Arab _tha| 20 Arct _min| 21 Aren _ser| 22 Arrh _ela| 23 Arte _abs| 24 Arte _vul
25 Aspl _adi| 26 Aspl _rut| 27 Aspl _tri| 28 Athy _fil| 29 Atri _und| 30 Ball _nig| 31 Barb _vul| 32 Barb _con
33 Barb _rec| 34 Barb _ung| 35 Bell _per| 36 Berb _vul| 37 Betu _pen| 38 Betu _pub| 39 Blac _per| 40 Brac _syl
41 Brac _riv| 42 Brac _rut| 43 Brom _hor| 44 Bryo _rec| 45 Bryu _arg| 46 Bryu _cae| 47 Bryu _cap| 48 Budd _dav
49 Call _cus| 50 Call _vul| 51 Caly _sep| 52 Camp _int| 53 Card _fle| 54 Card _hir| 55 Care _fla| 56 Cata _rig
57 Cent _nig| 58 Cent _ery| 59 Cera _fon| 60 Cera _glo| 61 Cera _pur| 62 Chae _min| 63 Cham _ang| 64 Chen _pol
65 Cirs _arv| 66 Cirs _pal| 67 Cirs _vul| 68 Clad _sp.| 69 Conv _arv| 70 Cony _can| 71 Cory _ave| 72 Crat _mon
73 Crep _cap| 74 Crep _ves| 75 Cupr _mxn| 76 Cymb _mur| 77 Cyno _cri| 78 Dact _glo| 79 Dauc _car| 80 Desc _ces
81 Desc _fle| 82 Dicr _sco| 83 Digi _pur| 84 Dips _ful| 85 Dyop _fel| 86 Dryo _fil| 87 Echi _vul| 88 Elyt _rep
89 Epil _cil| 90 Epil _hir| 91 Epil _mon| 92 Epil _pal| 93 Epil _par| 94 Epil _sp.| 95 Epil _tet| 96 Equi
_arv
97 Erig _ace| 98 Eupa _can| 99 Euph _off| 100 Fest _ovi| 101 Fest _rub| 102 Fili _ulm| 103 Frag _ves| 104 Frax _exc
105 Gali _apa| 106 Gali _mol| 107 Gali _pal| 108 Gali _par| 109 Gali _sax| 110 Gali _ver| 111 Gera _dis| 112 Gera _mol
113 Gera _rob| 114 Geum _riv| 115 Geum _urb| 116 Glec _hed| 117 Grim _pul| 118 Hede _hel| 119 Hera _sph| 120 Hier _umb
121 Hier _sp.| 122 Holc _lan| 123 Hype _hum| 124 Hype _mon| 125 Hype _per| 126 Hype _pul| 127 Hype _tet| 128 Hypn _cup
129 Hypo _rad| 130 Ilex _aqu| 131 Impa _gla| 132 Junc _art| 133 Junc _buf| 134 Junc _eff| 135 Kind _pra| 136 Knau _arv
137 Lact _ser| 138 Lami _alb| 139 Lami _pur| 140 Laps _com| 141 Lath _pra| 142 Leon _his| 143 Leuc _vul| 144 Leyc _for
145 XCup _ley| 146 Lina _vul| 147 Linu _cat| 148 Loli _per| 149 Loph _sp.| 150 Lotu _cor| 151 Luzu _cam| 152 Luzu _mul
153 Luzu _syl| 154 Lyco _eur| 155 Matr _dis| 156 Medi _lup| 157 Meli _off| 158 Merc _per| 159 Moli _cae| 160 Myos _arv
161 Myos _dis| 162 Nard _str| 163 Odon _ver| 164 Oeno _bie| 165 Oeno _cam| 166 Orig _vul| 167 Past _sat| 168 Pelt _sp.
169 Phal _aru| 170 Phle _pra| 171 Picr _ech| 172 Pilo _off| 173 Pimp _sax| 174 Plan _lan| 175 Plan _maj| 176 Poa_
annu
177 Poa_ prat| 178 Poa_ prat| 179 Poa_ triv| 180 Poly _avi| 181 Poly _com| 182 Pote _ere| 183 Pote _rep| 184 Pote _ste
185 Prim _vul| 186 Prun _vul| 187 Prun _sp.| 188 Pseu _hor| 189 Puli _dys| 190 Quer _rob| 191 Raco _sp.| 192 Ranu _acr
193 Ranu _bul| 194 Ranu _rep| 195 Rese _lut| 196 Rhod _pon| 197 Rhyt _squ| 198 Ribe _sp.| 199 Rosa _arv| 200 Rosa _can
201 Rosa _pim| 202 Rosa _spi| 203 Rosa _sp.| 204 Rubu _fru| 205 Rubu _ida| 206 Rume _ace| 207 Rume _ace| 208 Rume _con
209 Rume _cri| 210 Sagi _pro| 211 Sali _cap| 212 Sali _cin| 213 Sali _sp.| 214 Samb _nig| 215 Sang _min| 216 Schi _apo
217 Schi _cra| 218 Scor _aut| 219 Scro _aur| 220 Scro _nod| 221 Sedu _acr| 222 Sedu _rup| 223 Sene _jac| 224 Sene _squ
225 Sene _vis| 226 Sene _vul| 227 Sola _dul| 228 Soli _can| 229 Sonc _arv| 230 Sonc _asp| 231 Sonc _ole| 232 Sorb _auc
233 Stac _syl| 234 Stel _med| 235 Succ _pra| 236 Tana _vul| 237 Tara _off| 238 Teuc _sco| 239 Thui _tam| 240 Tort _mur
241 Trag _pra| 242 Trif _cam| 243 Trif _dub| 244 Trif _mic| 245 Trif _pra| 246 Trif _rep| 247 Trip _ino| 248 Tris _fla
249 Tuss _far| 250 Ulex _gal| 251 Ulot _cri| 252 Urti _dio| 253 Vacc _myr| 254 Vale _off| 255 Verb _tha| 256 Verb _off
257 Vero _arv| 258 Vero _bec| 259 Vero _cha| 260 Vero _off| 261 Vero _per| 262 Vici _bit| 263 Vici _cra| 264 Vici _hir
265 Vici _oro| 266 Vici _sat| 267 Vici _sep| 268 Vici _tet| 269 Viol _arv| 270 Viol _can| 271 Viol _riv| 272 Viol _sp.
273 Vulp _bro|

SAMPLE NAMES
1 1 | 2 2 | 3 3 | 4 4 | 5 5 | 6 6 | 7 7
8 8 | 9 9 | 10 10 | 11 11 | 12 12 | 13 13 | 14 14
15 15 | 16 16 | 17 17 | 18 18 | 19 19 | 20 20 | 21 21
22 22 | 23 23 | 24 24 | 25 25 | 26 26 | 27 27 | 28 28
29 29 | 30 30 | 31 31 | 32 32 | 33 33 | 34 34 | 35 35
36 36 | 37 37 | 38 38 | 39 39 | 40 40 | 41 41 | 42 42
43 43 | 44 44 | 45 45 | 46 46 | 47 47 | 48 48 | 49 49
50 50 | 51 51 | 52 52 | 53 53 | 54 54 | 55 55 | 56 56
57 57 | 58 58 | 59 59 | 60 60 | 61 61 | 62 62 | 63 63
64 64 | 65 65 | 66 66 | 67 67 | 68 68 | 69 69 | 70 70
71 71 | 72 72 | 73 73 | 74 74 | 75 75 | 76 76 | 77 77
78 78 | 79 79 | 80 80 | 81 81 | 82 82 | 83 83 | 84 84
85 85 | 86 86 | 87 87 | 88 88 | 89 89 | 90 90 | 91 91
92 92 | 93 93 | 94 94 | 95 95 | 96 96 | 97 97 | 98 98
99 99 | 100 100 | 101 101 | 102 102 | 103 103 | 104 104 | 105 105
106 106 | 107 107 | 108 108 | 109 109 | 110 110 | 111 111 | 112 112

113 113 | 114 114 | 115 115 | 116 116 | 117 117 | 118 118 | 119 119
120 120 | 121 121 | 122 122 | 123 123 | 124 124 | 125 125 | 126 126
127 127 | 128 128 | 129 129 | 130 130 | 131 131 | 132 132 | 133 133
134 134 | 135 135 | 136 136 | 137 137 | 138 138 | 139 139 | 140 140
141 141 | 142 142 | 143 143 | 144 144 | 145 145 | 146 146 | 147 147
148 148 | 149 149 | 150 150 | 151 151 | 152 152 | 153 153 | 154 154
155 155 | 156 156 | 157 157 | 158 158 | 159 159 | 160 160 | 161 161
162 162 | 163 163 | 164 164 | 165 165 | 166 166 | 167 167 | 168 168
169 169 | 170 170 | 171 171 | 172 172 | 173 173 | 174 174 |

Omitted samples:
End of list of omissions

Omitted species:
End of list of omissions
Minimum group size for division: 5
Maximum number of indicators per division: 7
Maximum number of species in final tabulation: 100
Maximum level of divisions: 6
Machine readable copy is wanted
Weights for levels of pseudospecies:
1.0000 1.0000 1.0000
Indicator potentials for cut levels:
1 1 1
Species omitted from the list of potential indicators
End of list of omissions

Length of data array after defining pseudospecies 5145

Total number of species and pseudospecies 524

Number of species, excluding pseudospecies and ones with no occurrences 273
Sample weights:
Species weights:

****

DIVISION 1 (N= 174) I.E. GROUP *
Eigenvalue 0.278 at iteration 6
INDICATORS, together with their SIGN
Urti _dio1(+) Arrh _ela1(-) Tara _off1(-)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 2 (N= 160) i.e. group *0
1 2 3 4 5 17 18 19 20 21 22 23
24 25 26 27 28 29 30 31 32 33 34 35
36 37 38 39 40 41 42 43 44 45 46 47
48 49 50 51 52 53 54 55 56 57 58 59
60 61 62 63 64 65 66 67 68 69 70 71
72 73 74 75 76 77 78 79 80 81 82 83
84 85 86 87 88 89 90 91 92 93 94 95
96 97 98 99 100 101 102 103 104 105 106 107
108 109 110 111 112 113 114 115 116 117 118 119

120 121 122 123 124 125 126 127 128 129 130 131
132 133 134 135 136 137 138 139 140 141 142 143
144 145 146 147 148 149 150 151 152 153 157 158
159 160 161 162 163 164 165 166 167 168 169 170
171 172 173 174

BORDERLINE negatives (N= 7)
23 28 57 158 159 160 161

Items in POSITIVE group 3 (N= 14) i.e. group *1
6 7 8 9 10 11 12 13 14 15 16 154
155 156

MISCLASSIFIED positives (N= 3)
154 155 156

NEGATIVE PREFERENTIALS
Arrh _ela1(136, 3) Betu _pen1(35, 0) Cham _ang1(76, 2) Epil _par1(52, 2) Fest _rub1(85, 3) Hera _sph1(38, 0)
Plan _lan1(42, 0) Rubu _fru1(113, 2) Sene _jac1(89, 1) Sonc _asp1(52, 0) Tara _off1(99, 0) Arrh _ela2(117, 3)
Cham _ang2(42, 0) Dact _glo2(42, 1) Rubu _fru2(82, 0) Arrh _ela3(61, 1)

POSITIVE PREFERENTIALS
Acer _pse1(6, 4) Alli _pet1(0, 3) Arab _tha1(7, 4) Barb _con1(5, 6) Card _fle1(0, 7) Card _hir1(2, 5)
Cera _pur1(20, 4) Epil _mon1(55, 11) Gali _mol1(5, 3) Gera _rob1(34, 9) Hype _tet1(1, 3) Hypn _cup1(17, 3)
Kind _pra1(9, 5) Lath _pra1(7, 4) Leuc _vul1(17, 5) Loli _per1(36, 10) Myos _arv1(4, 3) Poly _com1(6, 3)
Sagi _pro1(14, 4) Schi _apo1(0, 8) Schi _cra1(4, 8) Sonc _ole1(14, 8) Urti _dio1(18, 11) Vero _bec1(0, 4)
Barb _con2(2, 3) Card _fle2(0, 7) Epil _mon2(8, 5) Gera _rob2(12, 6) Kind _pra2(7, 3) Loli _per2(21, 6)
Poly _com2(5, 3) Schi _apo2(0, 8) Schi _cra2(2, 8) Holc _lan3(10, 3)

NON-PREFERENTIALS
Agro _cap1(52, 3) Agro _sto1(32, 3) Brac _rut1(49, 4) Dact _glo1(67, 4) Desc _ces1(27, 3) Holc _lan1(90, 6)
Brac _rut2(38, 2) Fest _rub2(61, 3) Holc _lan2(62, 4)

End of level 1

****

DIVISION 2 (N= 160) I.E. GROUP *0
Eigenvalue 0.272 at iteration 7
INDICATORS, together with their SIGN
Vulp _bro1(-) Fest _rub1(+) Rubu _fru2(+) Epil _par1(-) Betu _pen1(-) Sonc _asp1(-) Eupa _can1(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 4 (N= 56) i.e. group *00
47 51 57 58 59 60 110 111 112 115 116 117
118 119 120 121 122 123 124 125 126 127 128 129
130 131 132 133 134 135 136 137 138 139 140 141
142 143 144 145 146 147 148 149 150 151 152 153
162 164 169 170 171 172 173 174

BORDERLINE negatives (N= 1)

MISCLASSIFIED negatives (N= 5)

47 51 60 111 112

Items in POSITIVE group 5 (N= 104) i.e. group *01
1 2 3 4 5 17 18 19 20 21 22 23
24 25 26 27 28 29 30 31 32 33 34 35
36 37 38 39 40 41 42 43 44 45 46 48
49 50 52 53 54 55 56 61 62 63 64 65
66 67 68 69 70 71 72 73 74 75 76 77
78 79 80 81 82 83 84 85 86 87 88 89
90 91 92 93 94 95 96 97 98 99 100 101
102 103 104 105 106 107 108 109 113 114 157 158
159 160 161 163 165 166 167 168

BORDERLINE positives (N= 12)
46 48 49 50 52 56 69 70 72 113 165 166

MISCLASSIFIED positives (N= 4)
27 37 104 163

NEGATIVE PREFERENTIALS
Agro _sto1(22, 10) Betu _pen1(25, 10) Betu _pub1(12, 10) Budd _dav1(12, 6) Cera _fon1(17, 7) Cirs _arv1(15, 10)
Desc _ces1(15, 12) Epil _pal1(19, 4) Epil _par1(31, 21) Eupa _can1(18, 0) Fest _ovi1(13, 8) Gali _apa1(18, 6)
Hier _sp.1(18, 8) Hypo _rad1(14, 12) Leon _his1(14, 6) Lina _vul1(21, 11) Linu _cat1(13, 4) Plan _maj1(20, 6)
Poa_ annu1(14, 8) Sali _cap1(13, 9) Sonc _asp1(31, 21) Tana _vul1(12, 1) Vero _arv1(13, 3) Vulp _bro1(31, 1)
Agro _sto2(12, 3) Betu _pen2(16, 4) Eupa _can2(15, 0) Lina _vul2(12, 4) Vulp _bro2(25, 0)

POSITIVE PREFERENTIALS
Crat _mon1(6, 25) Fest _rub1(14, 71) Frax _exc1(2, 24) Gera _rob1(6, 28) Brac _rut2(5, 33) Fest _rub2(7, 54)
Rubu _fru2(14, 68) Tara _off2(2, 24) Fest _rub3(1, 22) Rubu _fru3(2, 29)

NON-PREFERENTIALS
Agro _cap1(18, 34) Arrh _ela1(51, 85) Brac _rut1(11, 38) Cham _ang1(32, 44) Dact _glo1(18, 49) Epil _mon1(28, 27)
Hera _sph1(15, 23) Holc _lan1(43, 47) Loli _per1(8, 28) Plan _lan1(9, 33) Rubu _fru1(31, 82) Sene _jac1(33, 56)
Tara _off1(41, 58) Arrh _ela2(43, 74) Cham _ang2(14, 28) Dact _glo2(11, 31) Holc _lan2(29, 33) Sene _jac2(7, 23)
Arrh _ela3(19, 42)
****

DIVISION 3 (N= 14) I.E. GROUP *1
Eigenvalue 0.700 at iteration 4
INDICATORS, together with their SIGN
Arrh _ela1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 6 (N= 11) i.e. group *10
6 7 8 9 10 11 12 13 14 15 16

Items in POSITIVE group 7 (N= 3) i.e. group *11
154 155 156

NEGATIVE PREFERENTIALS
Agro _sto1(3, 0) Alli _pet1(3, 0) Arab _tha1(4, 0) Barb _con1(6, 0) Brac _rut1(4, 0) Card _fle1(7, 0)
Card _hir1(5, 0) Cera _pur1(4, 0) Desc _ces1(3, 0) Epil _mon1(11, 0) Fest _rub1(3, 0) Gali _mol1(3, 0)
Hypn _cup1(3, 0) Lath _pra1(4, 0) Leuc _vul1(5, 0) Myos _arv1(3, 0) Sagi _pro1(4, 0) Schi _apo1(8, 0)
Schi _cra1(8, 0) Urti _dio1(11, 0) Vero _bec1(4, 0) Barb _con2(3, 0) Card _fle2(7, 0) Epil _mon2(5, 0)

Fest _rub2(3, 0) Schi _apo2(8, 0) Schi _cra2(8, 0)

POSITIVE PREFERENTIALS
Acer _pse1(2, 2) Ange _syl1(0, 1) Arrh _ela1(0, 3) Call _vul1(0, 2) Clad _sp.1(0, 1) Dact _glo1(2, 2)
Dicr _sco1(0, 2) Dryo _fil1(0, 1) Epil _cil1(0, 2) Geum _riv1(0, 2) Holc _lan1(3, 3) Hype _tet1(0, 3)
Poly _com1(0, 3) Prim _vul1(0, 1) Rhod _pon1(0, 1) Rubu _fru1(0, 2) Thui _tam1(0, 1) Ulex _gal1(0, 2)
Viol _can1(0, 1) Arrh _ela2(0, 3) Dicr _sco2(0, 2) Gera _rob2(3, 3) Holc _lan2(1, 3) Hype _tet2(0, 1)
Poly _com2(0, 3) Arrh _ela3(0, 1) Dicr _sco3(0, 1) Gera _rob3(0, 1) Holc _lan3(0, 3) Poly _com3(0, 2)

NON-PREFERENTIALS
Agro _cap1(2, 1) Gera _rob1(6, 3) Kind _pra1(4, 1) Loli _per1(8, 2) Sonc _ole1(6, 2) Kind _pra2(2, 1)
Loli _per2(4, 2)

End of level 2

****

DIVISION 4 (N= 56) I.E. GROUP *00
Eigenvalue 0.325 at iteration 6
INDICATORS, together with their SIGN
Eupa _can1(+) Vulp _bro1(-) Agro _sto1(+) Fest _ovi1(+) Hera _sph1(-) Agro _cap1(-) Budd _dav1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 8 (N= 34) i.e. group *000
47 57 58 59 60 110 115 116 117 118 119 120
121 122 123 124 131 134 144 145 146 147 148 149
150 151 152 153 169 170 171 172 173 174

BORDERLINE negatives (N= 2)
110 131

MISCLASSIFIED negatives (N= 2)
47 57

Items in POSITIVE group 9 (N= 22) i.e. group *001
51 111 112 125 126 127 128 129 130 132 133 135
136 137 138 139 140 141 142 143 162 164

BORDERLINE positives (N= 1)
133

MISCLASSIFIED positives (N= 1)
51

NEGATIVE PREFERENTIALS
Agro _cap1(16, 2) Anis _ste1(7, 0) Anth _syl1(9, 0) Bryu _arg1(9, 2) Bryu _cap1(7, 0) Cera _pur1(11, 0)
Cirs _arv1(13, 2) Dact _glo1(15, 3) Desc _ces1(14, 1) Epil _mon1(22, 6) Fest _rub1(11, 3) Hera _sph1(15, 0)
Hypo _rad1(11, 3) Lina _vul1(16, 5) Linu _cat1(10, 3) Picr _ech1(10, 1) Pimp _sax1(7, 0) Sene _jac1(25, 8)
Tana _vul1(12, 0) Verb _tha1(8, 1) Vero _arv1(13, 0) Vulp _bro1(27, 4) Agro _cap2(7, 1) Cera _pur2(10, 0)
Dact _glo2(10, 1) Desc _ces2(11, 0) Fest _rub2(7, 0) Lina _vul2(10, 2) Tana _vul2(8, 0) Vulp _bro2(22, 3)
Vulp _bro3(8, 0)

POSITIVE PREFERENTIALS
Agro _sto1(6, 16) Budd _dav1(2, 10) Epil _hir1(2, 5) Eupa _can1(2, 16) Euph _off1(2, 5) Fest _ovi1(2, 11)

Plan _lan1(2, 7) Sali _cap1(3, 10) Sali _cin1(1, 7) Stac _syl1(2, 6) Trif _dub1(3, 8) Agro _sto2(1, 11)
Budd _dav2(2, 5) Eupa _can2(2, 13) Rubu _fru2(6, 8) Sali _cap2(2, 6) Eupa _can3(1, 7)

NON-PREFERENTIALS
Arrh _ela1(32, 19) Betu _pen1(16, 9) Betu _pub1(8, 4) Brac _rut1(8, 3) Cera _fon1(11, 6) Cham _ang1(23, 9)
Conv _arv1(4, 5) Epil _pal1(14, 5) Epil _par1(22, 9) Equi _arv1(8, 3) Gali _apa1(12, 6) Hier _sp.1(13, 5)
Holc _lan1(23, 20) Leon _his1(9, 5) Plan _maj1(15, 5) Poa_ annu1(7, 7) Rubu _fru1(17, 14) Sagi _pro1(6, 5)
Sonc _asp1(22, 9) Tara _off1(25, 16) Arrh _ela2(29, 14) Betu _pen2(11, 5) Cham _ang2(10, 4) Holc _lan2(20, 9)
Arrh _ela3(11, 8)
****

DIVISION 5 (N= 104) I.E. GROUP *01
Eigenvalue 0.330 at iteration 5
INDICATORS, together with their SIGN
Achi _mil2(+) Scor _aut1(+) Loli _per2(+) Leuc _vul1(+)
Maximum indicator score for negative group 1 Minimum indicator score for positive group 2

Items in NEGATIVE group 10 (N= 88) i.e. group *010

1	2	3	4	5	17	18	19	20	21	22	23
24	25	26	27	28	29	30	36	37	38	39	40
41	42	43	44	45	46	48	49	50	52	53	54
55	56	61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	88	89	90
91	92	93	94	95	96	97	98	99	100	103	104
105	106	107	108	109	113	114	157	158	159	160	161
165	166	167	168								

BORDERLINE negatives (N= 3)
56 103 167

Items in POSITIVE group 11 (N= 16) i.e. group *011

31	32	33	34	35	80	81	82	83	84	85	86
87	101	102	163								

MISCLASSIFIED positives (N= 2)
81 102

NEGATIVE PREFERENTIALS
Agro _cap1(34, 0) Brac _rut1(36, 2) Epil _par1(20, 1) Gera _rob1(27, 1) Vici _sep1(18, 0) Brac _rut2(31, 2)
Arrh _ela3(40, 2)

POSITIVE PREFERENTIALS
Achi _mil1(1, 11) Aren _ser1(0, 6) Arte _vul1(0, 5) Caly _sep1(1, 4) Cent _nig1(3, 5) Cera _fon1(3, 4)
Cera _glo1(0, 4) Cirs _arv1(5, 5) Cony _can1(0, 7) Crep _cap1(0, 4) Gera _mol1(2, 4) Hype _per1(1, 6)
Knau _arv1(0, 5) Lami _alb1(0, 4) Leuc _vul1(4, 9) Loli _per1(17, 11) Medi _lup1(1, 6) Myos _arv1(0, 4)
Past _sat1(0, 4) Picr _ech1(1, 5) Pilo _off1(4, 5) Poa_ annu1(3, 5) Poa_ prat1(10, 4) Prun _vul1(4, 4)
Rume _ace1(7, 8) Scor _aut1(7, 11) Sene _vis1(3, 4) Sonc _asp1(15, 6) Stel _med1(2, 4) Trif _cam1(2, 5)
Urti _dio1(6, 5) Vero _cha1(0, 5) Achi _mil2(0, 11) Aren _ser2(0, 5) Arte _vul2(0, 4) Cent _nig2(1, 5)
Cony _can2(0, 7) Crat _mon2(0, 4) Geum _urb2(7, 4) Knau _arv2(0, 5) Lami _alb2(0, 4) Leuc _vul2(4, 8)
Loli _per2(8, 11) Medi _lup2(0, 6) Past _sat2(0, 4) Pilo _off2(3, 4) Plan _lan2(7, 6) Rume _ace2(1, 4)
Scor _aut2(3, 8) Sene _jac2(13, 10) Sene _vis2(3, 4) Sonc _asp2(8, 5) Tara _off2(17, 7) Trif _cam2(0, 4)
Achi _mil3(0, 5) Loli _per3(0, 5) Medi _lup3(0, 5)

NON-PREFERENTIALS

Arrh _ela1(76, 9) Cham _ang1(34, 10) Crat _mon1(19, 6) Dact _glo1(39, 10) Epil _mon1(22, 5) Fest _rub1(61, 10)
Frax _exc1(21, 3) Geum _urb1(14, 4) Hera _sph1(20, 3) Holc _lan1(42, 5) Plan _lan1(25, 8) Rubu _fru1(68, 14)
Sene _jac1(44, 12) Tara _off1(49, 9) Arrh _ela2(66, 8) Cham _ang2(22, 6) Dact _glo2(23, 8) Fest _rub2(46, 8)
Holc _lan2(29, 4) Rubu _fru2(56, 12) Fest _rub3(17, 5) Rubu _fru3(24, 5)
****

DIVISION 6 (N= 11) I.E. GROUP *10
Eigenvalue 0.537 at iteration 3
INDICATORS, together with their SIGN
Agro _sto1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 12 (N= 8) i.e. group *100
6 7 8 9 10 11 12 13

Items in POSITIVE group 13 (N= 3) i.e. group *101
14 15 16

NEGATIVE PREFERENTIALS
Acer _pse1(2, 0) Agro _cap1(2, 0) Brac _rut1(4, 0) Call _cus1(2, 0) Card _hir1(5, 0) Dact _glo1(2, 0)
Desc _ces1(3, 0) Equi _arv1(2, 0) Fest _rub1(3, 0) Gali _mol1(3, 0) Geum _urb1(2, 0) Hypn _cup1(3, 0)
Lath _pra1(4, 0) Myos _dis1(2, 0) Poa_ prat1(2, 0) Schi _apo1(8, 0) Schi _cra1(8, 0) Scor _aut1(2, 0)
Sonc _ole1(6, 0) Barb _con2(3, 0) Brac _rut2(2, 0) Desc _ces2(2, 0) Equi _arv2(2, 0) Fest _rub2(3, 0)
Gera _rob2(3, 0) Kind _pra2(2, 0) Myos _arv2(2, 0) Poa_ prat2(2, 0) Schi _apo2(8, 0) Schi _cra2(8, 0)
Schi _cra3(2, 0)

POSITIVE PREFERENTIALS
Agro _sto1(0, 3) Alli _pet1(0, 3) Brac _riv1(0, 1) Card _fle1(4, 3) Cham _ang1(1, 1) Epil _pal1(0, 1)
Epil _par1(1, 1) Gali _apa1(0, 1) Gali _pal1(0, 1) Gali _sax1(0, 1) Junc _art1(0, 1) Junc _buf1(0, 1)
Plan _maj1(0, 1) Poa_ annu1(0, 2) Ranu _bul1(0, 1) Sagi _pro1(2, 2) Sene _jac1(0, 1) Sola _dul1(0, 2)
Stel _med1(0, 2) Tuss _far1(1, 1) Vero _bec1(1, 3) Card _fle2(4, 3) Epil _par2(0, 1) Sagi _pro2(0, 2)
Urti _dio2(0, 1) Vero _bec2(0, 2) Sagi _pro3(0, 1)

NON-PREFERENTIALS
Arab _tha1(3, 1) Barb _con1(5, 1) Cera _pur1(3, 1) Epil _mon1(8, 3) Gera _rob1(5, 1) Holc _lan1(2, 1)
Kind _pra1(3, 1) Leuc _vul1(4, 1) Loli _per1(5, 3) Myos _arv1(2, 1) Urti _dio1(8, 3) Epil _mon2(4, 1)
Loli _per2(3, 1)
****

DIVISION 7 (N= 3) I.E. GROUP *11
DIVISION FAILS - There are too few items

End of level 3

****

DIVISION 8 (N= 34) I.E. GROUP *000
Eigenvalue 0.379 at iteration 4
INDICATORS, together with their SIGN
Anth _syl1(-) Gali _apa1(-) Pimp _sax1(-) Cham _ang1(+) Agro _cap1(+)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 16 (N= 10) i.e. group *0000
115 116 117 118 119 120 121 122 123 124

Items in POSITIVE group 17 (N= 24) i.e. group *0001
47 57 58 59 60 110 131 134 144 145 146 147
148 149 150 151 152 153 169 170 171 172 173 174

NEGATIVE PREFERENTIALS
Anth _syl1(9, 0) Arte _vul1(3, 1) Cent _ery1(5, 1) Cera _fon1(7, 4) Cony _can1(4, 1) Crep _ves1(4, 0)
Gali _apa1(9, 3) Hier _sp.1(6, 7) Hype _per1(3, 3) Hypo _rad1(6, 5) Linu _cat1(6, 4) Medi _lup1(4, 1)
Picr _ech1(7, 3) Pimp _sax1(7, 0) Rume _cri1(4, 0) Sene _vis1(5, 1) Sola _dul1(3, 0) Sonc _asp1(10, 12)
Verb _tha1(4, 4) Vero _arv1(7, 6) Anth _syl2(5, 0) Gali _apa2(4, 1) Hypo _rad2(4, 0) Picr _ech2(3, 1)
Pimp _sax2(4, 0) Rume _cri2(3, 0) Sonc _asp2(5, 0) Vulp _bro2(10, 12) Arrh _ela3(5, 6) Vulp _bro3(7, 1)

POSITIVE PREFERENTIALS
Agro _cap1(0, 16) Agro _sto1(0, 6) Anis _ste1(1, 6) Betu _pen1(0, 16) Betu _pub1(0, 8) Bryu _arg1(0, 9)
Bryu _cap1(0, 7) Cera _pur1(0, 11) Cham _ang1(2, 21) Desc _ces1(1, 13) Epil _pal1(2, 12) Equi _arv1(1, 7)
Fest _rub1(1, 10) Lina _vul1(0, 16) Loli _per1(0, 5) Plan _maj1(0, 15) Poa_ annu1(0, 7) Rese _lut1(1, 5)
Sagi _pro1(0, 6) Tana _vul1(0, 12) Urti _dio1(1, 5) Agro _cap2(0, 7) Betu _pen2(0, 11) Cera _pur2(0, 10)
Cham _ang2(1, 9) Desc _ces2(1, 10) Fest _rub2(0, 7) Lina _vul2(0, 10) Rese _lut2(0, 5) Rubu _fru2(1, 5)
Tana _vul2(0, 8)

NON-PREFERENTIALS
Arrh _ela1(10, 22) Brac _rut1(3, 5) Cirs _arv1(3, 10) Dact _glo1(6, 9) Epil _mon1(7, 15) Epil _par1(4, 18)
Hera _sph1(6, 9) Holc _lan1(7, 16) Leon _his1(3, 6) Rubu _fru1(4, 13) Sene _jac1(9, 16) Tara _off1(9, 16)
Vulp _bro1(10, 17) Arrh _ela2(10, 19) Dact _glo2(4, 6) Holc _lan2(6, 14)
****

DIVISION 9 (N= 22) I.E. GROUP *001
Eigenvalue 0.398 at iteration 8
INDICATORS, together with their SIGN
Betu _pen1(-) Budd _dav1(-) Stac _syl1(+)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 18 (N= 12) i.e. group *0010
111 112 130 132 133 135 136 137 138 139 162 164

BORDERLINE negatives (N= 1)
135

Items in POSITIVE group 19 (N= 10) i.e. group *0011
51 125 126 127 128 129 140 141 142 143

NEGATIVE PREFERENTIALS
Barb _con1(3, 0) Betu _pen1(9, 0) Betu _pub1(3, 1) Brac _rut1(3, 0) Budd _dav1(9, 1) Dact _glo1(3, 0)
Epil _mon1(6, 0) Epil _pal1(4, 1) Fest _rub1(3, 0) Gali _apa1(5, 1) Gali _mol1(3, 0) Geum _urb1(4, 0)
Hier _sp.1(5, 0) Hype _per1(3, 1) Laps _com1(3, 1) Leon _his1(5, 0) Leuc _vul1(3, 0) Lina _vul1(4, 1)
Linu _cat1(3, 0) Loli _per1(3, 0) Myos _dis1(3, 0) Plan _maj1(4, 1) Poa_ annu1(6, 1) Sene _jac1(7, 1)
Sonc _ole1(4, 0) Trif _dub1(6, 2) Vulp _bro1(4, 0) Betu _pen2(5, 0) Budd _dav2(5, 0) Cham _ang2(4, 0)
Sali _cap2(5, 1) Trif _dub2(3, 0) Vulp _bro2(3, 0) Budd _dav3(4, 0)

POSITIVE PREFERENTIALS
Caly _sep1(0, 3) Cera _fon1(1, 5) Conv _arv1(1, 4) Epil _hir1(0, 5) Fest _ovi1(3, 8) Lotu _cor1(0, 3)
Rubu _fru1(5, 9) Rume _cri1(0, 3) Sali _cin1(2, 5) Sene _squ1(1, 3) Sonc _asp1(2, 7) Stac _syl1(0, 6)
Epil _hir2(0, 4) Rubu _fru2(3, 5) Arrh _ela3(3, 5) Eupa _can3(2, 5)

NON-PREFERENTIALS
Agro _sto1(7, 9) Arrh _ela1(10, 9) Cham _ang1(6, 3) Epil _par1(4, 5) Eupa _can1(8, 8) Euph _off1(3, 2)
Holc _lan1(11, 9) Plan _lan1(4, 3) Sagi _pro1(3, 2) Sali _cap1(6, 4) Tara _off1(8, 8) Agro _sto2(6, 5)
Arrh _ela2(7, 7) Eupa _can2(7, 6) Holc _lan2(6, 3)
****

DIVISION 10 (N= 88) I.E. GROUP *010
Eigenvalue 0.320 at iteration 5
INDICATORS, together with their SIGN
Brac _rut2(+) Tara _off1(+) Fest _rub3(+) Dact _glo2(+) Vici _sep1(+) Arrh _ela3(-) Frax _exc1(-)
Maximum indicator score for negative group 1 Minimum indicator score for positive group 2

Items in NEGATIVE group 20 (N= 60) i.e. group *0100
1 2 3 4 5 17 18 19 20 21 22 23
24 25 26 27 28 29 30 36 37 38 39 40
41 42 43 44 45 52 53 54 55 56 61 62
63 69 71 72 74 76 77 78 79 99 107 108
109 113 114 157 158 159 160 161 165 166 167 168

BORDERLINE negatives (N= 5)
69 71 72 74 99

Items in POSITIVE group 21 (N= 28) i.e. group *0101
46 48 49 50 64 65 66 67 68 70 73 75
88 89 90 91 92 93 94 95 96 97 98 100
103 104 105 106

BORDERLINE positives (N= 2)
73 75

MISCLASSIFIED positives (N= 3)
48 50 91

NEGATIVE PREFERENTIALS
Epil _cil1(16, 0) Frax _exc1(21, 0) Gera _rob1(23, 4) Hypn _cup1(15, 2) Loli _per1(14, 3) Frax _exc2(17, 0)
Arrh _ela3(35, 5)

POSITIVE PREFERENTIALS
Ange _syl1(0, 8) Brac _rut1(13, 23) Bryu _cap1(6, 7) Call _cus1(4, 7) Crat _mon1(6, 13) Dact _glo1(19, 20)
Desc _ces1(2, 10) Epil _par1(9, 11) Hera _sph1(8, 12) Hier _sp.1(1, 6) Kind _pra1(2, 6) Poa_ prat1(4, 6)
Ranu _acr1(0, 6) Scor _aut1(0, 7) Sonc _asp1(7, 8) Sonc _ole1(2, 6) Tara _off1(23, 26) Vale _off1(0, 6)
Vici _sep1(4, 14) Brac _rut2(8, 23) Bryu _cap2(0, 6) Dact _glo2(7, 16) Desc _ces2(1, 6) Fest _rub2(22, 24)
Sene _jac2(2, 11) Sonc _asp2(2, 6) Tara _off2(2, 15) Vale _off2(0, 6) Vici _sep2(2, 10) Brac _rut3(0, 6)
Fest _rub3(1, 16)

NON-PREFERENTIALS
Agro _cap1(27, 7) Arrh _ela1(57, 19) Cham _ang1(23, 11) Epil _mon1(15, 7) Fest _rub1(36, 25) Holc _lan1(24, 18)
Plan _lan1(17, 8) Rhyt _squ1(9, 6) Rubu _fru1(49, 19) Sene _jac1(27, 17) Arrh _ela2(51, 15) Cham _ang2(15, 7)
Holc _lan2(16, 13) Rubu _fru2(40, 16) Rubu _fru3(17, 7)
****

DIVISION 11 (N= 16) I.E. GROUP *011
Eigenvalue 0.525 at iteration 6
INDICATORS, together with their SIGN

Arte _vul1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 22 (N= 11) i.e. group *0110
80 81 82 83 84 85 86 87 101 102 163

Items in POSITIVE group 23 (N= 5) i.e. group *0111
31 32 33 34 35

NEGATIVE PREFERENTIALS
Arab _tha1(3, 0) Aren _ser1(6, 0) Bell _per1(3, 0) Cent _nig1(5, 0) Cera _fon1(4, 0) Cera _glo1(4, 0)
Cirs _vul1(3, 0) Crat _mon1(6, 0) Dips _ful1(3, 0) Epil _mon1(5, 0) Epil _sp.1(3, 0) Frax _exc1(3, 0)
Gali _ver1(3, 0) Gera _mol1(4, 0) Geum _urb1(4, 0) Holc _lan1(5, 0) Hype _per1(5, 1) Knau _arv1(5, 0)
Lami _alb1(4, 0) Lina _vul1(3, 0) Medi _lup1(6, 0) Myos _arv1(4, 0) Past _sat1(4, 0) Picr _ech1(5, 0)
Pilo _off1(5, 0) Poa_ annu1(5, 0) Prun _vul1(4, 0) Rosa _pim1(3, 0) Rosa _spi1(3, 0) Sene _vis1(4, 0)
Sola _dul1(3, 0) Sonc _asp1(6, 0) Trif _rep1(3, 0) Urti _dio1(5, 0) Vero _arv1(3, 0) Vero _cha1(5, 0)
Aren _ser2(5, 0) Cent _nig2(5, 0) Cham _ang2(6, 0) Crat _mon2(4, 0) Dips _ful2(3, 0) Gali _ver2(3, 0)
Gera _mol2(3, 0) Geum _urb2(4, 0) Holc _lan2(4, 0) Hype _per2(3, 0) Knau _arv2(5, 0) Lami _alb2(4, 0)
Medi _lup2(6, 0) Myos _arv2(3, 0) Past _sat2(4, 0) Pilo _off2(4, 0) Poa_ annu2(3, 0) Sene _vis2(4, 0)
Sola _dul2(3, 0) Sonc _asp2(5, 0) Medi _lup3(5, 0)

POSITIVE PREFERENTIALS
Aira _car1(0, 2) Anis _ste1(0, 2) Arrh _ela1(4, 5) Arte _vul1(0, 5) Caly _sep1(0, 4) Cony _can1(2, 5)
Crep _cap1(0, 4) Desc _fle1(0, 2) Fest _rub1(5, 5) Hypo _rad1(0, 2) Nard _str1(0, 2) Poa_ prat1(0, 4)
Sagi _pro1(0, 3) Trag _pra1(0, 3) Trif _cam1(0, 5) Arrh _ela2(3, 5) Arte _vul2(0, 4) Caly _sep2(0, 3)
Cony _can2(2, 5) Crep _cap2(0, 3) Dact _glo2(4, 4) Fest _rub2(3, 5) Poa_ prat2(0, 2) Sagi _pro2(0, 2)
Trif _cam2(0, 4) Achi _mil3(0, 5) Fest _rub3(2, 3) Loli _per3(0, 5)

NON-PREFERENTIALS
Achi _mil1(6, 5) Cham _ang1(7, 3) Cirs _arv1(4, 1) Dact _glo1(6, 4) Leuc _vul1(6, 3) Loli _per1(6, 5)
Plan _lan1(5, 3) Rubu _fru1(10, 4) Rume _ace1(6, 2) Scor _aut1(8, 3) Sene _jac1(7, 5) Stel _med1(3, 1)
Tara _off1(6, 3) Achi _mil2(6, 5) Leuc _vul2(6, 2) Loli _per2(6, 5) Plan _lan2(4, 2) Rubu _fru2(8, 4)
Rume _ace2(3, 1) Scor _aut2(6, 2) Sene _jac2(6, 4) Tara _off2(4, 3) Rubu _fru3(3, 2)
****

DIVISION 12 (N= 8) I.E. GROUP *100
Eigenvalue 0.473 at iteration 2
INDICATORS, together with their SIGN
Brac _rut1(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 24 (N= 4) i.e. group *1000
10 11 12 13

Items in POSITIVE group 25 (N= 4) i.e. group *1001
6 7 8 9

NEGATIVE PREFERENTIALS
Agro _cap1(2, 0) Arab _tha1(3, 0) Barb _con1(4, 1) Brac _rut1(4, 0) Card _hir1(4, 1) Cera _pur1(3, 0)
Dact _glo1(2, 0) Desc _ces1(2, 1) Equi _arv1(2, 0) Fest _rub1(3, 0) Frax _exc1(1, 0) Gali _mol1(2, 1)
Glec _hed1(1, 0) Grim _pul1(1, 0) Holc _lan1(2, 0) Hypo _rad1(1, 0) Kind _pra1(3, 0) Laps _com1(1, 0)
Lath _pra1(3, 1) Leuc _vul1(3, 1) Loli _per1(4, 1) Myos _arv1(2, 0) Myos _dis1(2, 0) Scor _aut1(2, 0)
Sene _vul1(1, 0) Tort _mur1(1, 0) Barb _con2(3, 0) Brac _rut2(2, 0) Cera _pur2(1, 0) Dact _glo2(1, 0)
Desc _ces2(2, 0) Equi _arv2(2, 0) Fest _rub2(3, 0) Holc _lan2(1, 0) Kind _pra2(2, 0) Loli _per2(3, 0)

Myos _arv2(2, 0)

POSITIVE PREFERENTIALS
Acer _pse1(0, 2) Card _fle1(0, 4) Cham _ang1(0, 1) Epil _par1(0, 1) Gera _rob1(1, 4) Hype _pul1(0, 1)
Hypn _cup1(0, 3) Ranu _rep1(0, 1) Rume _ace1(0, 1) Tuss _far1(0, 1) Vero _bec1(0, 1) Card _fle2(0, 4)
Card _hir2(0, 1) Epil _mon2(1, 3) Gera _rob2(1, 2) Card _fle3(0, 1) Schi _cra3(0, 2)

NON-PREFERENTIALS
Call _cus1(1, 1) Epil _mon1(4, 4) Geum _urb1(1, 1) Poa_ prat1(1, 1) Sagi _pro1(1, 1) Schi _apo1(4, 4)
Schi _cra1(4, 4) Sonc _ole1(3, 3) Urti _dio1(4, 4) Poa_ prat2(1, 1) Schi _apo2(4, 4) Schi _cra2(4, 4)
****

DIVISION 13 (N= 3) I.E. GROUP *101
DIVISION FAILS - There are too few items

End of level 4

****

DIVISION 16 (N= 10) I.E. GROUP *0000
Eigenvalue 0.249 at iteration 9
INDICATORS, together with their SIGN
Cham _ang1(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 32 (N= 2) i.e. group *00000
121 122

Items in POSITIVE group 33 (N= 8) i.e. group *00001
115 116 117 118 119 120 123 124

NEGATIVE PREFERENTIALS
Cham _ang1(2, 0) Epil _par1(2, 2) Hera _sph1(2, 4) Leon _his1(1, 2) Medi _lup1(2, 2) Plan _lan1(1, 0)
Rume _cri1(2, 2) Samb _nig1(1, 0) Scro _nod1(1, 0) Cham _ang2(1, 0) Hier _sp.2(1, 0) Holc _lan2(2, 4)
Picr _ech2(1, 2) Rume _cri2(1, 2) Samb _nig2(1, 0) Scro _nod2(1, 0)

POSITIVE PREFERENTIALS
Arte _vul1(0, 3) Brac _rut1(0, 3) Cent _ery1(0, 5) Cera _glo1(0, 2) Cirs _arv1(0, 3) Cony _can1(0, 4)
Crep _ves1(0, 4) Dact _glo1(0, 6) Epil _pal1(0, 2) Hype _per1(0, 3) Hypo _rad1(0, 6) Rubu _fru1(0, 4)
Sene _vis1(0, 5) Sola _dul1(0, 3) Stac _syl1(0, 2) Tara _off1(1, 8) Trag _pra1(0, 2) Verb _tha1(0, 4)
Vici _cra1(0, 2) Anth _syl2(0, 5) Brac _rut2(0, 2) Cirs _arv2(0, 2) Cony _can2(0, 2) Dact _glo2(0, 4)
Gali _apa2(0, 4) Hypo _rad2(0, 4)

NON-PREFERENTIALS
Anth _syl1(2, 7) Arrh _ela1(2, 8) Cera _fon1(2, 5) Epil _mon1(1, 6) Gali _apa1(2, 7) Hier _sp.1(1, 5)
Holc _lan1(2, 5) Linu _cat1(1, 5) Picr _ech1(1, 6) Pimp _sax1(2, 5) Sene _jac1(2, 7) Sonc _asp1(2, 8)
Vero _arv1(2, 5) Vulp _bro1(2, 8) Arrh _ela2(2, 8) Pimp _sax2(1, 3) Sonc _asp2(1, 4) Vulp _bro2(2, 8)
Arrh _ela3(1, 4) Vulp _bro3(1, 6)
****

DIVISION 17 (N= 24) I.E. GROUP *0001
Eigenvalue 0.381 at iteration 4
INDICATORS, together with their SIGN
Poa_ annu1(+) Lina _vul1(-) Loli _per1(+) Cera _pur2(+)

Maximum indicator score for negative group 1 Minimum indicator score for positive group 2

Items in NEGATIVE group 34 (N= 19) i.e. group *00010
47 131 134 144 145 146 147 148 149 150 151 152
153 169 170 171 172 173 174

BORDERLINE negatives (N= 1)
169

Items in POSITIVE group 35 (N= 5) i.e. group *00011
57 58 59 60 110

NEGATIVE PREFERENTIALS
Anis _ste1(6, 0) Betu _pen1(15, 1) Betu _pub1(8, 0) Bryu _arg1(9, 0) Bryu _cap1(7, 0) Cent _nig1(4, 0)
Cera _fon1(4, 0) Cirs _arv1(9, 1) Dact _glo1(9, 0) Desc _ces1(13, 0) Echi _vul1(4, 0) Epil _pal1(12, 0)
Epil _par1(17, 1) Equi _arv1(7, 0) Fest _rub1(9, 1) Hier _sp.1(7, 0) Lina _vul1(16, 0) Linu _cat1(4, 0)
Rese _lut1(5, 0) Scor _aut1(4, 0) Tana _vul1(12, 0) Verb _tha1(4, 0) Vulp _bro1(16, 1) Agro _cap2(7, 0)
Betu _pen2(10, 1) Cham _ang2(8, 1) Dact _glo2(6, 0) Desc _ces2(10, 0) Echi _vul2(4, 0) Fest _rub2(7, 0)
Holc _lan2(13, 1) Lina _vul2(10, 0) Rese _lut2(5, 0) Rubu _fru2(5, 0) Sene _jac2(4, 0) Tana _vul2(8, 0)
Verb _tha2(4, 0) Vulp _bro2(11, 1)

POSITIVE PREFERENTIALS
Brac _rut1(2, 3) Cera _pur1(6, 5) Conv _arv1(2, 2) Geum _urb1(0, 2) Loli _per1(1, 4) Merc _per1(0, 3)
Poa_ annu1(2, 5) Prim _vul1(0, 2) Rubu _fru1(8, 5) Stel _med1(0, 2) Urti _dio1(2, 3) Vero _arv1(3, 3)
Vici _sat1(1, 3) Cera _pur2(5, 5) Loli _per2(0, 2) Arrh _ela3(2, 4)

NON-PREFERENTIALS
Agro _cap1(14, 2) Agro _sto1(5, 1) Arrh _ela1(17, 5) Cham _ang1(16, 5) Epil _mon1(12, 3) Hera _sph1(6, 3)
Holc _lan1(14, 2) Hypo _rad1(4, 1) Leon _his1(5, 1) Plan _maj1(12, 3) Sagi _pro1(4, 2) Sene _jac1(11, 5)
Sonc _asp1(9, 3) Tara _off1(14, 2) Arrh _ela2(14, 5)
****

DIVISION 18 (N= 12) I.E. GROUP *0010
Eigenvalue 0.522 at iteration 4
INDICATORS, together with their SIGN
Arrh _ela1(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 36 (N= 10) i.e. group *00100
111 112 130 132 133 135 136 137 138 139

Items in POSITIVE group 37 (N= 2) i.e. group *00101
162 164

NEGATIVE PREFERENTIALS
Arrh _ela1(10, 0) Barb _con1(3, 0) Betu _pub1(3, 0) Brac _rut1(3, 0) Cham _ang1(6, 0) Epil _pal1(4, 0)
Eupa _can1(8, 0) Euph _off1(3, 0) Fest _ovi1(3, 0) Fest _rub1(3, 0) Gali _apa1(5, 0) Gali _mol1(3, 0)
Leon _his1(5, 0) Linu _cat1(3, 0) Loli _per1(3, 0) Myos _dis1(3, 0) Sali _cap1(6, 0) Sonc _ole1(4, 0)
Trif _dub1(6, 0) Vulp _bro1(4, 0) Arrh _ela2(7, 0) Betu _pen2(5, 0) Cham _ang2(4, 0) Eupa _can2(7, 0)
Holc _lan2(6, 0) Sali _cap2(5, 0) Trif _dub2(3, 0) Vulp _bro2(3, 0) Arrh _ela3(3, 0) Budd _dav3(4, 0)

POSITIVE PREFERENTIALS
Agro _sto1(5, 2) Ball _nig1(0, 2) Brac _syl1(0, 1) Card _hir1(0, 1) Cera _fon1(0, 1) Cirs _vul1(1, 1)
Dact _glo1(2, 1) Desc _fle1(0, 1) Epil _mon1(4, 2) Equi _arv1(0, 1) Frag _ves1(0, 1) Gera _rob1(0, 2)

Geum _urb1(2, 2) Hede _hel1(0, 1) Hier _sp.1(3, 2) Hype _per1(1, 2) Junc _art1(0, 1) Junc _buf1(0, 1)
Junc _eff1(0, 1) Laps _com1(2, 1) Leuc _vul1(2, 1) Medi _lup1(0, 1) Meli _off1(0, 1) Orig _vul1(0, 1)
Poa_ annu1(4, 2) Prun _vul1(0, 1) Ranu _acr1(0, 1) Ranu _rep1(1, 1) Rume _ace1(0, 1) Sagi _pro1(2, 1)
Scor _aut1(0, 1) Scro _aur1(0, 2) Sene _jac1(5, 2) Sonc _asp1(0, 2) Stel _med1(0, 1) Trif _pra1(1, 1)
Trif _rep1(0, 2) Trip _ino1(0, 1) Verb _tha1(0, 1) Vero _cha1(0, 1) Vici _sep1(0, 1) Viol _sp.1(0, 1)
Agro _sto2(4, 2) Ball _nig2(0, 1) Epil _mon2(1, 1) Frag _ves2(0, 1) Gera _rob2(0, 1) Geum _urb2(0, 1)
Hype _per2(0, 1) Junc _buf2(0, 1) Leuc _vul2(0, 1) Medi _lup2(0, 1) Orig _vul2(0, 1) Poa_ annu2(0, 1)
Rubu _fru2(2, 1) Rume _ace2(0, 1) Sagi _pro2(0, 1) Vici _sep2(0, 1) Viol _sp.2(0, 1) Agro _sto3(0, 2)
Junc _buf3(0, 1) Viol _sp.3(0, 1)

NON-PREFERENTIALS
Betu _pen1(7, 2) Budd _dav1(8, 1) Epil _par1(3, 1) Holc _lan1(9, 2) Lina _vul1(3, 1) Plan _lan1(3, 1)
Plan _maj1(3, 1) Rubu _fru1(4, 1) Tara _off1(6, 2) Budd _dav2(4, 1)
****

DIVISION 19 (N= 10) I.E. GROUP *0011
Eigenvalue 0.425 at iteration 3
INDICATORS, together with their SIGN
Eupa _can3(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 38 (N= 5) i.e. group *00110
51 125 126 127 129

Items in POSITIVE group 39 (N= 5) i.e. group *00111
128 140 141 142 143

NEGATIVE PREFERENTIALS
Acer _pse1(2, 0) Caly _sep1(2, 1) Cham _ang1(2, 1) Conv _arv1(3, 1) Crat _mon1(2, 0) Epil _par1(4, 1)
Rume _cri1(2, 1) Sali _cap1(3, 1) Sene _squ1(3, 0) Vici _cra1(2, 0) Arrh _ela3(4, 1)

POSITIVE PREFERENTIALS
Arte _vul1(0, 2) Cera _fon1(1, 4) Epil _cil1(0, 2) Equi _arv1(0, 2) Euph _off1(0, 2) Hier _umb1(0, 2)
Hypo _rad1(0, 2) Lotu _cor1(0, 3) Plan _lan1(1, 2) Poa_ prat1(0, 2) Ranu _rep1(0, 2) Scro _nod1(0, 2)
Trif _dub1(0, 2) Trif _rep1(0, 2) Tuss _far1(0, 2) Vici _hir1(0, 2) Agro _sto2(1, 4) Eupa _can2(1, 5)
Fest _ovi2(0, 2) Holc _lan2(0, 3) Sali _cin2(0, 2) Agro _sto3(0, 2) Eupa _can3(0, 5)

NON-PREFERENTIALS
Agro _sto1(4, 5) Arrh _ela1(5, 4) Epil _hir1(2, 3) Eupa _can1(3, 5) Fest _ovi1(4, 4) Holc _lan1(4, 5)
Rubu _fru1(5, 4) Sali _cin1(3, 2) Sonc _asp1(3, 4) Stac _syl1(3, 3) Tara _off1(4, 4) Arrh _ela2(4, 3)
Epil _hir2(2, 2) Rubu _fru2(2, 3)
****

DIVISION 20 (N= 60) I.E. GROUP *0100
Eigenvalue 0.331 at iteration 8
INDICATORS, together with their SIGN
Holc _lan2(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 40 (N= 17) i.e. group *01000
1 2 3 4 5 23 28 29 30 107 108 157
158 159 160 161 166

BORDERLINE negatives (N= 3)

23 107 166

MISCLASSIFIED negatives (N= 1)

5

Items in POSITIVE group 41 (N= 43) i.e. group *01001

17 18 19 20 21 22 24 25 26 27 36 37
38 39 40 41 42 43 44 45 52 53 54 55
56 61 62 63 69 71 72 74 76 77 78 79
99 109 113 114 165 167 168

BORDERLINE positives (N= 2)

22 109

NEGATIVE PREFERENTIALS

Anth _odo1(5, 0) Brac _rut1(6, 7) Bryu _cap1(5, 1) Call _vul1(4, 0) Camp _int1(4, 1) Epil _cil1(9, 7)
Epil _par1(4, 5) Epil _tet1(4, 0) Gera _rob1(12, 11) Geum _riv1(4, 0) Hede _hel1(7, 1) Holc _lan1(16, 8)
Lina _vul1(4, 2) Loli _per1(10, 4) Lotu _cor1(5, 1) Plan _lan1(10, 7) Poly _com1(5, 0) Agro _cap2(5, 3)
Anth _odo2(5, 0) Brac _rut2(4, 4) Dact _glo2(4, 3) Epil _cil2(6, 0) Epil _tet2(4, 0) Gera _rob2(6, 2)
Hede _hel2(6, 1) Holc _lan2(16, 0) Loli _per2(5, 2) Lotu _cor2(4, 0) Plan _lan2(6, 0) Poly _com2(4, 0)
Anth _odo3(5, 0) Gera _rob3(5, 0) Holc _lan3(5, 0)

POSITIVE PREFERENTIALS

Hypn _cup1(1, 14) Tara _off1(3, 20) Hypn _cup2(0, 11)

NON-PREFERENTIALS

Agro _cap1(8, 19) Arrh _ela1(15, 42) Cham _ang1(6, 17) Dact _glo1(7, 12) Epil _mon1(3, 12) Equi _arv1(4, 7)
Fest _rub1(10, 26) Frax _exc1(6, 15) Geum _urb1(4, 8) Rubu _fru1(13, 36) Sene _jac1(9, 18) Arrh _ela2(13, 38)
Cham _ang2(5, 10) Fest _rub2(4, 18) Frax _exc2(5, 12) Rubu _fru2(9, 31) Arrh _ela3(8, 27) Rubu _fru3(3, 14)
****

DIVISION 21 (N= 28) I.E. GROUP *0101

Eigenvalue 0.446 at iteration 4

INDICATORS, together with their SIGN

Epil _par1(-) Vici _sep1(+) Rubu _fru3(-) Desc _ces1(+) Call _cus1(-) Tara _off2(+)

Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 42 (N= 12) i.e. group *01010

46 48 49 50 64 65 66 67 68 70 73 75

BORDERLINE negatives (N= 1)

70

Items in POSITIVE group 43 (N= 16) i.e. group *01011

88 89 90 91 92 93 94 95 96 97 98 100
103 104 105 106

BORDERLINE positives (N= 1)

90

NEGATIVE PREFERENTIALS

Agro _cap1(5, 2) Anth _syl1(4, 1) Brom _hor1(4, 0) Bryo _rec1(5, 0) Call _cus1(6, 1) Cera _fon1(3, 0)
Cera _pur1(5, 0) Epil _mon1(6, 1) Epil _pal1(3, 0) Epil _par1(10, 1) Fest _ovi1(3, 1) Kind _pra1(6, 0)
Leon _his1(4, 0) Leuc _vul1(4, 0) Linu _cat1(4, 0) Plan _lan1(6, 2) Pote _rep1(3, 0) Rume _ace1(4, 0)

Sali _cap1(3, 0) Scor _aut1(5, 2) Sonc _ole1(5, 1) Trif _dub1(4, 0) Trif _pra1(3, 0) Tuss _far1(3, 0)
Vici _sat1(4, 0) Call _cus2(4, 1) Epil _par2(3, 1) Kind _pra2(5, 0) Leon _his2(4, 0) Leuc _vul2(4, 0)
Rubu _fru2(10, 6) Rubu _fru3(7, 0)

POSITIVE PREFERENTIALS
Alop _pra1(0, 5) Ange _syl1(0, 8) Arab _tha1(0, 4) Betu _pub1(0, 4) Bryu _cap1(0, 7) Cham _ang1(1, 10)
Desc _ces1(0, 10) Epil _sp.1(0, 5) Hera _sph1(2, 10) Hier _umb1(0, 4) Hypo _rad1(1, 4) Lath _pra1(0, 4)
Poa_ prat1(0, 6) Pote _ste1(0, 5) Rhyt _squ1(0, 6) Rubu _ida1(0, 4) Sonc _asp1(1, 7) Vici _sep1(1, 13)
Alop _pra2(0, 4) Ange _syl2(0, 5) Bryu _cap2(0, 6) Cham _ang2(0, 7) Dact _glo2(4, 12) Desc _ces2(0, 6)
Epil _sp.2(0, 5) Hera _sph2(0, 5) Hypo _rad2(0, 4) Lath _pra2(0, 4) Poa_ prat2(0, 4) Sene _jac2(3, 8)
Sonc _asp2(0, 6) Tara _off2(3, 12) Vici _sep2(1, 9) Brac _rut3(0, 6) Fest _rub3(4, 12)

NON-PREFERENTIALS
Arrh _ela1(11, 8) Brac _rut1(8, 15) Crat _mon1(5, 8) Dact _glo1(8, 12) Fest _rub1(10, 15) Hier _sp.1(3, 3)
Holc _lan1(7, 11) Ranu _acr1(3, 3) Rubu _fru1(10, 9) Sene _jac1(8, 9) Tara _off1(12, 14) Vale _off1(2, 4)
Arrh _ela2(8, 7) Brac _rut2(8, 15) Fest _rub2(9, 15) Holc _lan2(4, 9) Vale _off2(2, 4)
****

DIVISION 22 (N= 11) I.E. GROUP *0110
Eigenvalue 0.539 at iteration 3
INDICATORS, together with their SIGN
Ange _syl1(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 44 (N= 2) i.e. group *01100
101 102

Items in POSITIVE group 45 (N= 9) i.e. group *01101
80 81 82 83 84 85 86 87 163

NEGATIVE PREFERENTIALS
Ambl _ser1(1, 0) Ange _syl1(2, 0) Arab _tha1(2, 1) Barb _rec1(1, 0) Bell _per1(1, 2) Brac _rut1(2, 0)
Call _cus1(1, 0) Cera _fon1(2, 2) Cirs _vul1(2, 1) Dact _glo1(2, 4) Epil _sp.1(2, 1) Fest _rub1(2, 3)
Fili _ulm1(1, 0) Hera _sph1(1, 1) Hier _umb1(2, 0) Kind _pra1(1, 0) Laps _com1(1, 1) Lina _vul1(2, 1)
Loph _sp.1(1, 0) Plan _maj1(1, 1) Poa_ annu1(2, 3) Pote _ste1(1, 0) Raco _sp.1(1, 0) Ranu _acr1(1, 1)
Rhyt _squ1(1, 0) Rosa _arv1(1, 0) Rubu _ida1(1, 0) Sali _sp.1(1, 0) Scro _nod1(1, 1) Sola _dul1(1, 2)
Sonc _asp1(2, 4) Tara _off1(2, 4) Trif _rep1(1, 2) Vale _off1(1, 0) Vero _arv1(2, 1) Vici _cra1(1, 0)
Vici _hir1(1, 0) Vici _sat1(2, 0) Ambl _ser2(1, 0) Ange _syl2(2, 0) Arab _tha2(2, 0) Barb _rec2(1, 0)
Bell _per2(1, 0) Brac _rut2(2, 0) Call _cus2(1, 0) Cera _fon2(1, 0) Cham _ang2(2, 4) Epil _sp.2(2, 0)
Fest _rub2(2, 1) Fili _ulm2(1, 0) Hier _umb2(1, 0) Lina _vul2(2, 0) Loph _sp.2(1, 0) Plan _maj2(1, 1)
Poa_ annu2(2, 1) Pote _ste2(1, 0) Raco _sp.2(1, 0) Rhyt _squ2(1, 0) Rosa _arv2(1, 0) Rubu _ida2(1, 0)
Scro _nod2(1, 0) Sene _jac2(2, 4) Sola _dul2(1, 2) Sonc _asp2(2, 3) Tara _off2(2, 2) Trif _rep2(1, 1)
Vero _arv2(1, 0) Vici _cra2(1, 0) Vici _hir2(1, 0) Vici _sat2(2, 0) Brac _rut3(1, 0) Fest _rub3(2, 0)
Holc _lan3(1, 0) Poa_ annu3(2, 0) Vici _cra3(1, 0)

POSITIVE PREFERENTIALS
Achi _mil1(0, 6) Arrh _ela1(0, 4) Brac _syl1(0, 2) Cent _nig1(0, 5) Cera _glo1(0, 4) Cony _can1(0, 2)
Crat _mon1(0, 6) Dauc _car1(0, 2) Dips _ful1(0, 3) Epil _mon1(0, 5) Equi _arv1(0, 2) Frax _exc1(0, 3)
Gali _ver1(0, 3) Gera _dis1(0, 2) Gera _mol1(0, 4) Geum _urb1(0, 4) Glec _hed1(0, 2) Hype _per1(0, 5)
Knau _arv1(0, 5) Lami _alb1(0, 4) Lami _pur1(0, 2) Medi _lup1(0, 6) Myos _arv1(0, 4) Past _sat1(0, 4)
Picr _ech1(0, 5) Prun _vul1(0, 4) Rosa _pim1(0, 3) Rosa _spi1(0, 3) Rume _ace1(0, 6) Scor _aut1(0, 8)
Sene _vis1(0, 4) Stac _syl1(0, 2) Stel _med1(0, 3) Verb _tha1(0, 2) Viol _can1(0, 2) Achi _mil2(0, 6)
Aren _ser2(0, 5) Arrh _ela2(0, 3) Brac _syl2(0, 2) Cent _nig2(0, 5) Cony _can2(0, 2) Crat _mon2(0, 4)
Dips _ful2(0, 3) Epil _mon2(0, 2) Gali _ver2(0, 3) Gera _mol2(0, 3) Geum _urb2(0, 4) Glec _hed2(0, 2)

Hype _per2(0, 3) Knau _arv2(0, 5) Lami _alb2(0, 4) Lami _pur2(0, 2) Medi _lup2(0, 6) Myos _arv2(0, 3) Past _sat2(0, 4) Pilo _off2(0, 4) Rosa _pim2(0, 2) Rosa _spi2(0, 2) Rume _ace2(0, 3) Scor _aut2(0, 6) Sene _vis2(0, 4) Verb _tha2(0, 2) Vero _cha2(0, 2) Medi _lup3(0, 5) Rubu _fru3(0, 3)

NON-PREFERENTIALS
Aren _ser1(1, 5) Cham _ang1(2, 5) Cirs _arv1(1, 3) Holc _lan1(1, 4) Leuc _vul1(1, 5) Loli _per1(1, 5) Pilo _off1(1, 4) Plan _lan1(1, 4) Rubu _fru1(2, 8) Sene _jac1(2, 5) Urti _dio1(1, 4) Vero _cha1(1, 4) Dact _glo2(1, 3) Holc _lan2(1, 3) Leuc _vul2(1, 5) Loli _per2(1, 5) Plan _lan2(1, 3) Rubu _fru2(1, 7)
****

DIVISION 23 (N= 5) I.E. GROUP *0111
Eigenvalue 0.266 at iteration 1
INDICATORS, together with their SIGN
Aira _car1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 46 (N= 3) i.e. group *01110
33 34 35

Items in POSITIVE group 47 (N= 2) i.e. group *01111
31 32

NEGATIVE PREFERENTIALS
Agro _sto1(1, 0) Anis _ste1(2, 0) Cirs _arv1(1, 0) Elyt _rep1(1, 0) Hede _hel1(1, 0) Poa_ prat1(3, 1) Poa_ prat1(1, 0) Rosa _can1(1, 0) Rume _ace1(2, 0) Scor _aut1(3, 0) Stel _med1(1, 0) Succ _pra1(1, 0) Tara _off1(3, 0) Arte _vul2(3, 1) Elyt _rep2(1, 0) Leuc _vul2(2, 0) Plan _lan2(2, 0) Poa_ prat2(2, 0) Poa_ prat2(1, 0) Rume _ace2(1, 0) Scor _aut2(2, 0) Sene _jac2(3, 1) Stel _med2(1, 0) Tara _off2(3, 0) Trif _cam2(3, 1) Arrh _ela3(1, 0) Dact _glo3(1, 0)

POSITIVE PREFERENTIALS
Aira _car1(0, 2) Desc _fle1(0, 2) Hera _sph1(0, 1) Hype _per1(0, 1) Matr _dis1(0, 1) Nard _str1(0, 2) Sagi _pro1(1, 2) Crep _cap2(1, 2) Sagi _pro2(0, 2) Rubu _fru3(0, 2) Trif _cam3(0, 1)

NON-PREFERENTIALS
Achi _mil1(3, 2) Arrh _ela1(3, 2) Arte _vul1(3, 2) Caly _sep1(2, 2) Cham _ang1(2, 1) Cony _can1(3, 2) Crep _cap1(2, 2) Dact _glo1(2, 2) Fest _rub1(3, 2) Hypo _rad1(1, 1) Leuc _vul1(2, 1) Loli _per1(3, 2) Plan _lan1(2, 1) Rubu _fru1(2, 2) Sene _jac1(3, 2) Trag _pra1(2, 1) Trif _cam1(3, 2) Achi _mil2(3, 2) Arrh _ela2(3, 2) Caly _sep2(2, 1) Cony _can2(3, 2) Dact _glo2(2, 2) Fest _rub2(3, 2) Loli _per2(3, 2) Rubu _fru2(2, 2) Achi _mil3(3, 2) Fest _rub3(2, 1) Loli _per3(3, 2)
****

DIVISION 24 (N= 4) I.E. GROUP *1000
DIVISION FAILS - There are too few items
****

DIVISION 25 (N= 4) I.E. GROUP *1001
DIVISION FAILS - There are too few items

End of level 5

****

DIVISION 32 (N= 2) I.E. GROUP *00000
DIVISION FAILS - There are too few items

****

DIVISION 33 (N= 8) I.E. GROUP *00001
Eigenvalue 0.276 at iteration 3
INDICATORS, together with their SIGN
Brac _rut1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 66 (N= 5) i.e. group *000010
118 119 120 123 124

BORDERLINE negatives (N= 1)
118

Items in POSITIVE group 67 (N= 3) i.e. group *000011
115 116 117

NEGATIVE PREFERENTIALS
Crep _ves1(4, 0) Hype _per1(3, 0) Medi _lup1(2, 0) Sene _vis1(4, 1) Stac _syl1(2, 0) Vici _cra1(2, 0)
Anth _syl2(4, 1)

POSITIVE PREFERENTIALS
Anis _ste1(0, 1) Arte _vul1(1, 2) Brac _rut1(0, 3) Cent _ery1(2, 3) Cera _fon1(2, 3) Cirs _arv1(1, 2)
Cirs _vul1(0, 1) Cony _can1(1, 3) Desc _ces1(0, 1) Epil _par1(0, 2) Equi _arv1(0, 1) Gera _rob1(0, 1)
Hera _sph1(1, 3) Leon _his1(0, 2) Linu _cat1(2, 3) Rese _lut1(0, 1) Rubu _fru1(1, 3) Rume _ace1(0, 1)
Rume _ace1(0, 1) Rume _cri1(0, 2) Sola _dul1(1, 2) Anis _ste2(0, 1) Arte _vul2(0, 1) Brac _rut2(0, 2)
Cony _can2(0, 2) Desc _ces2(0, 1) Gali _apa2(1, 3) Hera _sph2(0, 1) Hypo _rad2(1, 3) Pimp _sax2(1, 2)
Rubu _fru2(0, 1) Rume _cri2(0, 2) Sene _jac2(0, 1) Tara _off2(0, 1) Trag _pra2(0, 1) Verb _tha2(0, 1)

NON-PREFERENTIALS
Anth _syl1(5, 2) Arrh _ela1(5, 3) Cera _glo1(1, 1) Dact _glo1(4, 2) Epil _mon1(3, 3) Epil _pal1(1, 1)
Gali _apa1(4, 3) Hier _sp.1(3, 2) Holc _lan1(3, 2) Hypo _rad1(3, 3) Picr _ech1(4, 2) Pimp _sax1(3, 2)
Sene _jac1(4, 3) Sonc _asp1(5, 3) Tara _off1(5, 3) Trag _pra1(1, 1) Verb _tha1(2, 2) Vero _arv1(3, 2)
Vulp _bro1(5, 3) Arrh _ela2(5, 3) Cirs _arv2(1, 1) Dact _glo2(3, 1) Holc _lan2(2, 2) Picr _ech2(1, 1)
Sonc _asp2(2, 2) Vulp _bro2(5, 3) Arrh _ela3(3, 1) Vulp _bro3(3, 3)
****

DIVISION 34 (N= 19) I.E. GROUP *00010
Eigenvalue 0.347 at iteration 7
INDICATORS, together with their SIGN
Fest _rub2(-) Rubu _fru1(-)
Maximum indicator score for negative group -2 Minimum indicator score for positive group -1

Items in NEGATIVE group 68 (N= 6) i.e. group *000100
47 170 171 172 173 174

Items in POSITIVE group 69 (N= 13) i.e. group *000101
131 134 144 145 146 147 148 149 150 151 152 153
169

BORDERLINE positives (N= 1)
169

NEGATIVE PREFERENTIALS

Bryu _cap1(5, 2) Cent _nig1(3, 1) Cera _fon1(2, 2) Cirs _arv1(5, 4) Cirs _vul1(2, 0) Crat _mon1(2, 0)
Dact _glo1(6, 3) Echi _vul1(4, 0) Epil _hir1(2, 0) Epil _mon1(6, 6) Erig _ace1(2, 0) Fest _rub1(6, 3)
Frax _exc1(2, 0) Hier _sp.1(5, 2) Hype _per1(3, 0) Lact _ser1(3, 0) Linu _cat1(3, 1) Picr _ech1(3, 0)
Pote _rep1(3, 0) Rese _lut1(4, 1) Rubu _fru1(6, 2) Sonc _asp1(5, 4) Verb _tha1(4, 0) Cent _nig2(2, 1)
Dact _glo2(5, 1) Echi _vul2(4, 0) Erig _ace2(2, 0) Fest _rub2(6, 1) Hier _sp.2(2, 0) Hype _per2(2, 0)
Lact _ser2(2, 0) Lina _vul2(5, 5) Plan _maj2(2, 0) Rese _lut2(4, 1) Rubu _fru2(5, 0) Tana _vul2(5, 3)
Verb _tha2(4, 0)

POSITIVE PREFERENTIALS
Agro _sto1(0, 5) Anis _ste1(1, 5) Betu _pub1(1, 7) Cera _pur1(0, 6) Desc _ces1(2, 11) Hypo _rad1(0, 4)
Sagi _pro1(0, 4) Sali _cap1(0, 3) Scor _aut1(0, 4) Sene _jac1(1, 10) Anis _ste2(0, 3) Cera _pur2(0, 5)
Desc _ces2(0, 10) Equi _arv2(0, 3) Sene _jac2(0, 4)

NON-PREFERENTIALS
Agro _cap1(3, 11) Arrh _ela1(5, 12) Betu _pen1(5, 10) Bryu _arg1(2, 7) Cham _ang1(6, 10) Epil _pal1(4, 8)
Epil _par1(6, 11) Equi _arv1(2, 5) Hera _sph1(2, 4) Holc _lan1(5, 9) Leon _his1(2, 3) Lina _vul1(5, 11)
Plan _maj1(4, 8) Tana _vul1(5, 7) Tara _off1(5, 9) Vulp _bro1(5, 11) Agro _cap2(2, 5) Arrh _ela2(4, 10)
Betu _pen2(4, 6) Cham _ang2(3, 5) Holc _lan2(5, 8) Vulp _bro2(5, 6)
****

DIVISION 35 (N= 5) I.E. GROUP *00011
Eigenvalue 0.654 at iteration 1
INDICATORS, together with their SIGN
Acer _pse1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 70 (N= 4) i.e. group *000110
57 58 59 60

Items in POSITIVE group 71 (N= 1) i.e. group *000111
110

NEGATIVE PREFERENTIALS
Agro _sto1(1, 0) Anag _arv1(1, 0) Aspl _rut1(1, 0) Brac _rut1(3, 0) Cirs _arv1(1, 0) Crat _mon1(1, 0)
Gali _mol1(1, 0) Glec _hed1(1, 0) Hera _sph1(3, 0) Merc _per1(3, 0) Plan _maj1(3, 0) Prim _vul1(2, 0)
Rume _ace1(1, 0) Sonc _asp1(3, 0) Stel _med1(2, 0) Tara _off1(2, 0) Urti _dio1(3, 0) Vero _arv1(3, 0)
Vici _sat1(3, 0) Brac _rut2(1, 0) Cham _ang2(1, 0) Loli _per2(2, 0) Arrh _ela3(4, 0)

POSITIVE PREFERENTIALS
Acer _pse1(0, 1) Agro _cap1(1, 1) Betu _pen1(0, 1) Budd _dav1(0, 1) Call _cus1(0, 1) Conv _arv1(1, 1)
Dips _ful1(0, 1) Epil _mon1(2, 1) Epil _par1(0, 1) Fest _rub1(0, 1) Gera _dis1(0, 1) Geum _urb1(1, 1)
Hede _hel1(0, 1) Holc _lan1(1, 1) Hype _pul1(0, 1) Hypo _rad1(0, 1) Laps _com1(0, 1) Leon _his1(0, 1)
Plan _lan1(0, 1) Prun _vul1(0, 1) Rhyt _squ1(0, 1) Sagi _pro1(1, 1) Trag _pra1(0, 1) Trif _cam1(0, 1)
Trif _dub1(0, 1) Vici _hir1(0, 1) Vulp _bro1(0, 1) Betu _pen2(0, 1) Budd _dav2(0, 1) Holc _lan2(0, 1)
Leon _his2(0, 1) Rhyt _squ2(0, 1) Trif _dub2(0, 1) Vici _hir2(0, 1) Vulp _bro2(0, 1) Budd _dav3(0, 1)

NON-PREFERENTIALS
Arrh _ela1(4, 1) Cera _pur1(4, 1) Cham _ang1(4, 1) Loli _per1(3, 1) Poa_ annu1(4, 1) Rubu _fru1(4, 1)
Sene _jac1(4, 1) Arrh _ela2(4, 1) Cera _pur2(4, 1)
****

DIVISION 36 (N= 10) I.E. GROUP *00100
Eigenvalue 0.486 at iteration 3
INDICATORS, together with their SIGN

Vulp _bro1(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 72 (N= 4) i.e. group *001000
130 132 133 139

Items in POSITIVE group 73 (N= 6) i.e. group *001001
111 112 135 136 137 138

NEGATIVE PREFERENTIALS
Agro _cap1(2, 0) Agro _sto1(4, 1) Alnu _glu1(2, 0) Barb _con1(3, 0) Betu _pub1(3, 0) Brac _rut1(3, 0)
Bryu _arg1(2, 0) Cent _nig1(2, 0) Cent _ery1(2, 0) Cham _ang1(4, 2) Cirs _vul1(1, 0) Dact _glo1(2, 0)
Dauc _car1(2, 0) Epil _par1(3, 0) Euph _off1(2, 1) Fest _rub1(3, 0) Gali _apa1(4, 1) Gali _mol1(2, 1)
Hype _mon1(1, 0) Hypo _rad1(1, 0) Laps _com1(2, 0) Leon _his1(3, 2) Leuc _vul1(2, 0) Linu _cat1(3, 0)
Loli _per1(2, 1) Lyco _eur1(1, 0) Myos _dis1(3, 0) Past _sat1(2, 0) Picr _ech1(1, 0) Plan _lan1(2, 1)
Poa_ annu1(3, 1) Pseu _hor1(1, 0) Puli _dys1(1, 0) Ranu _rep1(1, 0) Rhyt _squ1(1, 0) Sali _cin1(2, 0)
Sene _jac1(3, 2) Sene _squ1(1, 0) Sonc _ole1(3, 1) Trif _pra1(1, 0) Vici _sat1(2, 0) Vulp _bro1(4, 0)
Agro _cap2(1, 0) Agro _sto2(4, 0) Alnu _glu2(2, 0) Barb _con2(2, 0) Brac _rut2(1, 0) Bryu _arg2(1, 0)
Cham _ang2(3, 1) Dact _glo2(1, 0) Epil _mon2(1, 0) Epil _par2(1, 0) Eupa _can2(4, 3) Euph _off2(1, 0)
Fest _ovi2(1, 0) Linu _cat2(1, 0) Past _sat2(1, 0) Sali _cin2(2, 0) Sene _jac2(2, 0) Trif _dub2(3, 0)
Vulp _bro2(3, 0) Betu _pen3(1, 0) Eupa _can3(2, 0)

POSITIVE PREFERENTIALS
Geum _urb1(0, 2) Lina _vul1(0, 3) Rubu _fru1(1, 3) Trag _pra1(0, 2) Arrh _ela2(1, 6) Budd _dav2(0, 4)
Lina _vul2(0, 2) Rubu _fru2(0, 2) Arrh _ela3(0, 3) Budd _dav3(0, 4)

NON-PREFERENTIALS
Arrh _ela1(4, 6) Betu _pen1(3, 4) Budd _dav1(3, 5) Epil _mon1(2, 2) Epil _pal1(2, 2) Erig _ace1(1, 1)
Eupa _can1(4, 4) Fest _ovi1(1, 2) Hier _sp.1(1, 2) Holc _lan1(4, 5) Plan _maj1(1, 2) Sagi _pro1(1, 1)
Sali _cap1(2, 4) Tara _off1(3, 3) Trif _dub1(3, 3) Betu _pen2(2, 3) Holc _lan2(3, 3) Sali _cap2(2, 3)
****

DIVISION 37 (N= 2) I.E. GROUP *00101
DIVISION FAILS - There are too few items
****

DIVISION 38 (N= 5) I.E. GROUP *00110
Eigenvalue 0.502 at iteration 1
INDICATORS, together with their SIGN
Agro _sto1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 76 (N= 1) i.e. group *001100
51

Items in POSITIVE group 77 (N= 4) i.e. group *001101
125 126 127 129

NEGATIVE PREFERENTIALS
Brom _hor1(1, 0) Conv _arv1(1, 2) Epil _pal1(1, 0) Sali _cap1(1, 2) Sene _jac1(1, 0) Trag _pra1(1, 0)
Rubu _fru2(1, 1) Sali _cap2(1, 0)

POSITIVE PREFERENTIALS
Acer _pse1(0, 2) Agro _sto1(0, 4) Caly _sep1(0, 2) Cera _fon1(0, 1) Cham _ang1(0, 2) Crat _mon1(0, 2)

Epil _hir1(0, 2) Epil _sp.1(0, 1) Eupa _can1(0, 3) Fest _ovi1(0, 4) Gera _rob1(0, 1) Holc _lan1(0, 4)
Lina _vul1(0, 1) Medi _lup1(0, 1) Plan _lan1(0, 1) Poa_ annu1(0, 1) Prun _sp.1(0, 1) Rume _cri1(0, 2)
Sagi _pro1(0, 1) Sali _cin1(0, 3) Sene _squ1(0, 3) Sonc _asp1(0, 3) Stac _syl1(0, 3) Vici _cra1(0, 2)
Agro _sto2(0, 1) Caly _sep2(0, 1) Conv _arv2(0, 1) Epil _hir2(0, 2) Epil _par2(0, 1) Eupa _can2(0, 1)
Medi _lup2(0, 1)

NON-PREFERENTIALS
Arrh _ela1(1, 4) Epil _par1(1, 3) Rubu _fru1(1, 4) Tara _off1(1, 3) Arrh _ela2(1, 3) Arrh _ela3(1, 3)
****

DIVISION 39 (N= 5) I.E. GROUP *00111
Eigenvalue 0.442 at iteration 1
INDICATORS, together with their SIGN
Lotu _cor1(-)
Maximum indicator score for negative group -1 Minimum indicator score for positive group 0

Items in NEGATIVE group 78 (N= 3) i.e. group *001110
128 140 141

Items in POSITIVE group 79 (N= 2) i.e. group *001111
142 143

NEGATIVE PREFERENTIALS
Betu _pub1(1, 0) Caly _sep1(1, 0) Cent _ery1(1, 0) Cera _fon1(3, 1) Cham _ang1(1, 0) Conv _arv1(1, 0)
Crep _cap1(1, 0) Desc _ces1(1, 0) Fest _ovi1(3, 1) Gali _apa1(1, 0) Hype _per1(1, 0) Hypo _rad1(2, 0)
Laps _com1(1, 0) Lotu _cor1(3, 0) Plan _lan1(2, 0) Plan _maj1(1, 0) Rosa _can1(1, 0) Sagi _pro1(1, 0)
Sali _cap1(1, 0) Soli _can1(1, 0) Tara _off1(3, 1) Trif _dub1(2, 0) Trif _pra1(1, 0) Tuss _far1(2, 0)
Agro _sto2(3, 1) Lotu _cor2(1, 0) Agro _sto3(2, 0) Arrh _ela3(1, 0)

POSITIVE PREFERENTIALS
Budd _dav1(0, 1) Cirs _arv1(0, 1) Epil _par1(0, 1) Gera _rob1(0, 1) Medi _lup1(0, 1) Oeno _cam1(0, 1)
Poa_ prat1(0, 2) Rume _cri1(0, 1) Scro _nod1(0, 2) Sola _dul1(0, 1) Stac _syl1(1, 2) Arte _vul2(0, 1)
Equi _arv2(0, 1) Euph _off2(0, 1) Medi _lup2(0, 1) Rubu _fru2(1, 2) Tara _off2(0, 1) Trif _rep2(0, 1)
Euph _off3(0, 1) Holc _lan3(0, 1) Medi _lup3(0, 1) Rubu _fru3(0, 1)

NON-PREFERENTIALS
Agro _sto1(3, 2) Arrh _ela1(2, 2) Arte _vul1(1, 1) Epil _cil1(1, 1) Epil _hir1(2, 1) Equi _arv1(1, 1)
Eupa _can1(3, 2) Euph _off1(1, 1) Hier _umb1(1, 1) Holc _lan1(3, 2) Ranu _rep1(1, 1) Rubu _fru1(2, 2)
Sali _cin1(1, 1) Sonc _asp1(2, 2) Trif _rep1(1, 1) Vici _hir1(1, 1) Arrh _ela2(2, 1) Epil _hir2(1, 1)
Eupa _can2(3, 2) Fest _ovi2(1, 1) Holc _lan2(2, 1) Sali _cin2(1, 1) Eupa _can3(3, 2)
****

DIVISION 40 (N= 17) I.E. GROUP *01000
Eigenvalue 0.526 at iteration 4
INDICATORS, together with their SIGN
Sene _jac1(+) Rubu _fru2(+) Cham _ang1(-) Gera _rob3(-) Hede _hel1(+)
Maximum indicator score for negative group 0 Minimum indicator score for positive group 1

Items in NEGATIVE group 80 (N= 7) i.e. group *010000
23 157 158 159 160 161 166

Items in POSITIVE group 81 (N= 10) i.e. group *010001
1 2 3 4 5 28 29 30 107 108

NEGATIVE PREFERENTIALS
Bryu _cap1(3, 2) Call _vul1(3, 1) Cham _ang1(6, 0) Epil _cil1(6, 3) Epil _tet1(4, 0) Frag _ves1(3, 0)
Gera _mol1(2, 0) Geum _riv1(4, 0) Geum _urb1(3, 1) Lath _pra1(3, 0) Lotu _cor1(4, 1) Prun _vul1(2, 1)
Quer _rob1(2, 0) Rhyt _squ1(2, 1) Sonc _ole1(2, 0) Vici _oro1(2, 0) Cham _ang2(5, 0) Epil _cil2(5, 1)
Epil _tet2(4, 0) Gera _rob2(5, 1) Lotu _cor2(4, 0) Arrh _ela3(6, 2) Gera _rob3(5, 0) Lotu _cor3(2, 0)

POSITIVE PREFERENTIALS
Agro _cap1(2, 6) Agro _sto1(0, 3) Anth _odo1(0, 5) Atri _und1(0, 3) Brac _rut1(0, 6) Camp _int1(0, 4)
Dact _glo1(1, 6) Epil _hir1(0, 3) Epil _par1(0, 4) Equi _arv1(1, 3) Frax _exc1(1, 5) Hede _hel1(0, 7)
Lina _vul1(1, 3) Moli _cae1(0, 3) Plan _lan1(2, 8) Poly _com1(1, 4) Schi _cra1(0, 3) Sene _jac1(0, 9)
Tara _off1(0, 3) Agro _cap2(0, 5) Anth _odo2(0, 5) Brac _rut2(0, 4) Dact _glo2(0, 4) Fest _rub2(1, 3)
Frax _exc2(0, 5) Hede _hel2(0, 6) Moli _cae2(0, 3) Plan _lan2(1, 5) Poly _com2(1, 3) Rubu _fru2(0, 9)
Anth _odo3(0, 5) Moli _cae3(0, 3) Rubu _fru3(0, 3)

NON-PREFERENTIALS
Arrh _ela1(7, 8) Fest _rub1(3, 7) Gera _rob1(5, 7) Holc _lan1(7, 9) Loli _per1(5, 5) Rubu _fru1(4, 9)
Arrh _ela2(7, 6) Holc _lan2(7, 9) Loli _per2(2, 3) Holc _lan3(2, 3)
****

DIVISION 41 (N= 43) I.E. GROUP *01001
Eigenvalue 0.344 at iteration 20
INDICATORS, together with their SIGN
Agro _cap1(-) Epil _mon1(+) Hypn _cup1(-) Arrh _ela3(+) Rubu _fru2(+) Brac _rut1(+) Bryo _rec1(+)
Maximum indicator score for negative group 1 Minimum indicator score for positive group 2

Items in NEGATIVE group 82 (N= 24) i.e. group *010010

17	18	19	20	21	22	24	25	26	27	36	37
38	39	40	41	42	43	44	45	69	71	74	99

Items in POSITIVE group 83 (N= 19) i.e. group *010011

52	53	54	55	56	61	62	63	72	76	77	78
79	109	113	114	165	167	168					

MISCLASSIFIED positives (N= 1)
72

NEGATIVE PREFERENTIALS
Agro _cap1(18, 1) Dact _glo1(10, 2) Epil _cil1(7, 0) Epil _hir1(5, 0) Gera _rob1(10, 1) Hera _sph1(7, 0)
Hypn _cup1(14, 0) Hypo _rad1(5, 0) Impa _gla1(6, 0) Quer _rob1(5, 1) Sonc _asp1(5, 1) Sorb _auc1(5, 0)
Teuc _sco1(6, 0) Viol _riv1(6, 0) Fest _rub2(13, 5) Hypn _cup2(11, 0) Frax _exc3(6, 1)

POSITIVE PREFERENTIALS
Brac _rut1(0, 7) Bryo _rec1(0, 7) Budd _dav1(2, 4) Elyt _rep1(0, 4) Epil _mon1(0, 12) Equi _arv1(2, 5)
Geum _urb1(2, 6) Poa_ prat1(0, 4) Rhyt _squ1(1, 5) Brac _rut2(0, 4) Elyt _rep2(0, 4) Equi _arv2(0, 4)
Arrh _ela3(9, 18)

NON-PREFERENTIALS
Arrh _ela1(23, 19) Betu _pen1(5, 2) Cham _ang1(10, 7) Fest _rub1(17, 9) Frax _exc1(9, 6) Holc _lan1(4, 4)
Plan _lan1(5, 2) Rubu _fru1(17, 19) Sene _jac1(12, 6) Tara _off1(14, 6) Arrh _ela2(19, 19) Cham _ang2(6, 4)
Frax _exc2(7, 5) Rubu _fru2(13, 18) Rubu _fru3(7, 7)
****